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NUTRITIONAL STUDIES WITH FRAGARIA

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The results to be described were the outgrowth of an attempt to study in sand cultures the effect of nitrogen starvation on strawberry plants at different stages of their growth period. The first attempts at this nitrogen starvation project met with a disastrous ending owing to lack of available information concerning a suitable formula and optimum concentrations.

A formula referred to here as McMurtrey's formula was obtained from J. E. McMurtrey, United States Department of Agriculture, which gave fairly satisfactory growth and productiveness at the concentrations suggested, but this formula did not meet the demands of our work, as nitrogen was present in more than one combination and could not be withdrawn without completely destroying the entire formula.

A second formula, which had been previously used for nutritional studies with apple trees and originally supplied by Dr. E. J. Kraus, was also used at different concentrations and will be referred to as formula A. This is a no-nitrogen formula, not containing that element in any form.

A third formula, devised by us, was also used and is designated as formula B. This also is a no-nitrogen formula.

Nitrogen was supplied, except in the case of the McMurtrey formula, in the form of ammonium nitrate, this salt being used on account of its high nitrogen content, which enabled the use of satisfactory quantities of nitrogen without excessive total salt concentration.

In order to study the effect of various concentrations upon the strawberry plant the nutrient solution was divided into two portions, one portion consisting of mineral elements* only and the other portion containing nitrogen. Twenty-one series of pots were then used, in which the concentrations of the mineral portion and the nitrogen portion of the solution were varied over a wide range, according to Table 1. The result was that a series of cultures were available, which constituted a basis of study for ratio between nitrogen and the mineral elements.

Duggar (*1*) points out that as early as 1883 Von Raumer established the value of calcium in modifying the toxic action of magnesium and further states that the importance of a balanced ratio between calcium and magnesium is now clear.

*Minerals as used here include the element chlorine.

Tottingham (*2*, page 146) calls attention to the fact that Lucanus concluded that the molecular ratio of calcium to potassium in the medium should be two to one for clover. Osterhout (*3*) found that antagonisms existed between sodium and calcium and sodium and potassium.

Pouget and Chouchak (*4*), in an investigation of Mitscherlich's "law of the minimum", concluded that the amount of NO_3 absorbed from a nutrient solution was proportional to the concentration of NO_3 up to a point where the plant could no longer assimilate nitrate as rapidly as entrance occurred. Thus the excess absorption of nitrate resulting in its accumulation within the plant was established. On the other hand, at lower NO_3 concentrations, where a deficient supply of nitrogen existed, the yield decreased with the concentration. There appears, therefore, in the literature considerable evidence of the value of the balance of nutrient solutions, not only from the standpoint of the chemical reaction of the solution itself, but from the standpoint of the absorption of individual ions and their subsequent assimilation by the plant.

The question of correct ratio between component ions of the nutrient medium would seem to be quite as inviting a field for study as that of the determination of the optimum total salt concentration of the solution. Preliminary work, not reported on, indicated to the authors that quantities of nitrogen far beyond that which produced apparently normal plant growth and production could be efficiently absorbed and assimilated by the plant, providing that some sort of balance between nitrogen and minerals was maintained.

In an effort to determine the limits of salt concentrations and the relation of solutions of low and high concentration, both with and without nitrogen, the twenty-one series referred to below were established as a basis of study.

TABLE 1.—*Showing the treatment given and the total salt concentrations of the series studied.*

Series No.	Treatment	Total Salt Concentration	
I	McMurtrey Formula	.0098	Complete nutrient solution
II	Formula A (no nitrogen)	.0080	Formula A without nitrogen in varying concentrations.
III	" A × 2	.0160	
IV	" A × 3	.0240	
V	" A × 4	.0320	
VI	" A × 6	.0480	
VII	" A × 8	.0640	
VIII	" A × 10	.80	
IX	" B (no nitrogen)	.0062	Formula B without nitrogen in varying concentrations.
X	" B × 3	.0186	
XI	" B × 6	.0372	
XII	" B + N (normal nitrogen)	.0175	Complete nutrient solutions with minerals and nitrogen in varying ratio.
XIII	" 2B + 2N	.0350	
XIV	" 4B + 4N	.0700	
XV	" B + ¼N	.0090	
XVI	" B + 2N	.0288	
XVII	" 2B + 4N	.0576	
XVIII	" B + 4N	.0514	
XIX	" 3B + 3N	.0525	
XX	McMurtrey Formula × 2	.0196	
XXI	" " × 3	.0294	

Information Re Formulae Used

The formula supplied by J. E. McMurtrey was as follows:

$Ca(NO_3)_2$ 4 H_2O	2.9 grams	Water 100 cc.
KNO_3	.219 "	
$MgNO_3$ $6H_2O$	.319 "	
KH_2PO_4	.575 "	
$MgSO_4$ $7H_2O$	.308 "	

Dilute the above 100 times and use 400 cc. of the dilute solution to a 5 inch pot once per week.

The composition of Formula A was:

$MgSO_4$ $7H_2O$	720 mg.	Water 100 cc.
KH_2PO_4	575 "	
KCl	160 "	
$CaSO_4$ $2H_2O$	2107 "	

Dilute the above 100 times and use 400 cc. of the dilute solution per 5 inch pot once per week.

The composition of Formula B was:

$MgSO_4$ $7H_2O$	720 mg.	Water 100 cc.
KH_2PO_4	575 "	
KCl	160 "	
$Ca(OH)_2$	906.25 "	

Dilute the above 100 times and use 400 cc. of the dilute solution to a 5 inch pot once per week.

To the series receiving nitrogen, this was supplied in the form of NH_4NO_3 on the basis of the following concentration for a normal nitrogen application:

3452.50 Mg. NH_4NO_3
Water 100 cc.
Dilute 100 times and use 400 cc. per 5 inch pot once a week.

Thus series XII, for instance, received solution B plus the above concentration of nitrogen, while Series XV received a normal application of all minerals (Formula B) plus one-quarter of the above concentration of nitrogen.

Table 2, which follows, gives for each Series the per cent of elemental concentrations and the weight in milligrams of each element supplied per week per 5 inch pot. In calculating concentrations the molecules of water of crystallization were deducted and the weights of the solids only were used. It is to be understood that these concentrations are the calculated concentrations of the salts after application to the sand.

Procedure and Technique

In all, thirteen hundred and twenty individual 5 inch pots were used for the study. Strawberry plants of comparable vigour and size were selected and planted in these pots, one group being planted in a pure ground sandstone, the analysis of which was given by Davis (*5*), while the other group was

TABLE 2.—*Showing the weight in mg. and percent concentration of each element.*

	NITROGEN		CALCIUM		POTASSIUM		MAGNESIUM		PHOSPHOROUS		SULPHUR		CHLORINE	
	Wt. in mg.	Percent concentration	Wt. in mg.	Percent concentration	Wt. in mg.	Percent concentration	Wt. in mg.	Percent concentration	Wt. in mg.	Percent concentration	Wt. in mg.	Percent concentration	Wt. in mg.	Percent concentration
Series 1	15.7	.0012	19.60	.0015	9.92	.0008	2.81	.0002	5.25	.0004	3.1	.0002		
Series II	--	--	19.5	.0015	9.92	.0008	2.81	.0002	5.25	.0004	19.3	.0015	3.	.0002
Series III	--	--	39.	.0030	19.84	.0016	5.6	.0004	10.4	.0008	38.6	.0030	6.	.0004
Series IV	--	--	58.5	.0045	29.76	.0024	8.4	.0006	15.6	.0012	57.9	.0045	9.	.0006
Series V	--	--	78.	.0060	39.68	.0032	11.2	.0008	20.8	.0016	77.2	.0060	12.	.0008
Series VI	--	--	117.	.0090	59.52	.0048	16.8	.0012	31.2	.0024	115.8	.0090	18.	.0012
Series VII	--	--	156.	.0120	79.36	.0064	20.4	.0016	41.6	.0032	154.4	.0120	24.	.0016
Series VIII	--	--	195.	.0150	99.2	.0080	28.	.0020	52.	.0040	193.	.0150	30.	.0020
Series IX	--	--	19.5	.0015	9.92	.0008	2.8	.0002	5.2	.0004	3.7	.00029	3.	.0002
Series X	--	--	58.5	.0045	29.76	.0024	8.4	.0006	15.6	.0012	11.1	.00087	9.	.0006
Series XI	--	--	117.	.0090	59.52	.0048	16.8	.0012	31.2	.0024	22.2	.00174	18.	.0012
Series XII	48.	.0038	19.5	.0015	9.92	.0008	2.8	.0002	5.2	.0004	3.7	.00029	3.	.0002
Series XIII	96.	.0076	39.	.0030	19.84	.0016	5.6	.0004	10.4	.0008	7.4	.00058	6.	.0004
Series XIV	192.	.0152	78.	.0060	29.68	.0032	11.2	.0008	20.8	.0016	14.8	.00116	12.	.0008
Series XV	12.	.0009	19.5	.0015	9.92	.0008	2.8	.0002	5.2	.0004	3.7	.00029	3.	.0002
Series XVI	96.	.0076	19.5	.0015	9.92	.0008	2.8	.0002	5.2	.0004	3.7	.00029	3.	.0002
Series XVII	19.2	.0152	39.	.0030	19.84	.0016	5.6	.0004	10.4	.0008	7.4	.00058	6.	.0004
Series XVIII	19.2	.0152	19.5	.0015	9.92	.0008	2.8	.0002	5.2	.0004	3.7	.00029	3.	.0002
Series XIX	144.	.0114	58.5	.0045	29.76	.0024	8.4	.0006	15.6	.0012	11.1	.00087	9.	.0006
Series XX	31.4	.0024	39.20	.0030	19.84	.0016	5.62	.0004	10.5	.0008	6.2	.0004	--	--
Series XXI	47.1	.0036	58.8	.0045	29.76	.0024	8.43	.0006	15.75	.0012	9.3	.0006	--	--

planted in a good greenhouse potting soil. Each group was divided into the twenty-one series referred to in Table No. 1.

The pots were handled in cold frames, the sashes of which were removed as soon as warm weather set in, thus exposing the pots to the natural precipitation. In this way the actual salt concentration within the pot was not under control, but as all series were treated alike the conditions were taken as satisfactorily comparable. The pots were watched daily and when necessary additional water was added so that at no time did the moisture content vary much from the optimum.

Qualitative Data

Notes were taken on the appearance of the plants from time to time and a summary of these is given.

Dealing first with the group in pure sand, it was noted that all series where nitrogen was an absolute limiting factor soon showed the characteristic yellowing and dwarfing, followed by a reddening of the foliage. As the concentration of the no-nitrogen formula increased this characteristic reddening became more pronounced and appeared much earlier. Thus in Series II, which received normal applications of minerals, the plants continued into July before the actual reddening appeared, whereas Series VI, receiving six times as much minerals, showed this characteristic much earlier.

Series XII and XIII, receiving a full nutrient solution, appeared throughout the most vigorous series, exceeding Series I (McMurtrey Formula) but closely approached by Series XX and XXI. Those series receiving deficient nitrogen showed lack of vigour and lighter coloured foliage throughout, while excess, up to the extent of three times normal, resulted in little change in vigour from the normal, but the foliage took on a much darker colour and in some instances exhibited a bronzing and purpling which we have found to be associated with lack of phosphorous and potash in other experiments. By the time the nitrogen was in excess to the extent of four times normal the foliage was extremely dark green, very much reduced in vigour and in some cases showed definite injury.

In general, relative excess accumulation of nitrogen is evidenced by abnormally dark green foliage, with a distinct tendency to curl upwards, and frequently accompanied by a bronzing and a purpling on older leaves. Super-excess of nitrogen may result in an exhibition of symptoms much more pronounced, the foliage being somewhat darker and the injury more severe, sometimes causing the death of the plant.

Lack of nitrogen is evidenced by light green foliage, followed by a distinct yellowing and a bright red colouration of the older leaves.

The soil group exhibited exactly the same symptoms as did the sand group, except that in the case of the nitrogen starved series the nitrogen of the potting soil was sufficient to protect them against an exhibition of extreme distress. These series corresponded more closely with the sand series receiving deficient nitrogen.

Quantitative Data from the Sand Group

As a measure of response to the different treatments a count was made of the number of blossoms produced by the individual plants in the spring of 1927.

To determine the significance of the results obtained the probable error was calculated by the deviation from the mean method, as given by Hayes (6). By this method a probable error of 9.22% was obtained as the error for the mean of a single series in the sand group. The mean number of blossoms produced per series, with the probable error in terms of number, is given in Table 3 and the results portrayed graphically in Figure 1.

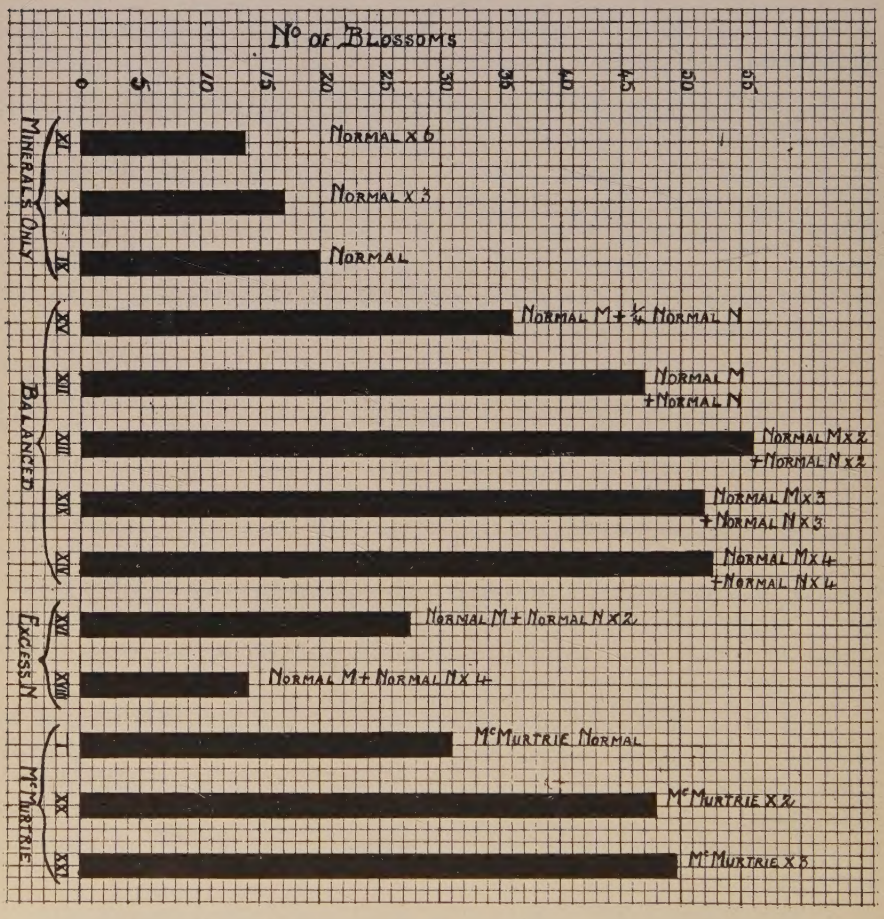

Figure 1

It will be observed (1) that the withdrawal of nitrogen very greatly reduced the number of blossoms produced, (2) that as the concentration of the mineral solution without nitrogen increased the production exhibited a distinct tendency to decrease, although in the case of solution A some variation in this respect occurred, (3) that it can be safely assumed that the difference between Series II and VIII is significant so that the increased

TABLE 3.—*Summary of the blossoms produced by the different series of the sand culture group.*

Series No.	Treatment	Mean of Number of Blossoms
I	McMurtrey	31.70 ± 2.92
II	A (No N.)	17.50 ± 1.61
III	A × 2	16.67 ± 1.54
IV	A × 3	11.45 ± 1.05
V	A × 4	13.80 ± 1.22
VI	A × 6	11.30 ± 1.04
VII	A × 8	15.67 ± 1.44
VIII	A × 10	11.67 ± 1.08
IX	B (No N.)	19.91 ± 1.84
X	B × 3	17.08 ± 1.57
XI	B × 6	13.67 ± 1.26
XII	B + Normal N	47.08 + 4.34
XIII	2B + 2N	55.83 ± 5.15
XIV	4B + 4N	52.83 ± 4.87
XV	B + Def. N	35.73 ± 3.29
XVI	B + 2N	27.50 ± 2.53
XVII	2B + 4N	30.20 ± 2.78
XVIII	1B + 4N	14.09 ± 1.30
XIX	3B + 3N	52.08 ± 4.80
XX	McMurtrey × 2	47.92 ± 4.42
XXI	" × 3	49.75 ± 4.59

N.B. Probable error in per cent = 9.22

quantities of minerals without nitrogen was of no avail in increasing production, (4) that as balance was restored between the minerals and nitrogen production became normal, (5) that to increase the nitrogen without a comparable increase of minerals may result in as low productivity as where nitrogen is entirely lacking, (6) that production reached its maximum when both minerals and nitrogen were double that of the normal, and (7) that even four times the strength of both minerals and nitrogen failed to produce any marked reduction in productivity. The importance of balance between minerals and nitrogen is clearly evident and the wide range of adaptability of the plant to total salt concentrations is readily apparent.

A comparison of the results from the McMurtrey formula is interesting. In the normal strength of this formula the weekly increment of nitrogen per pot was 15.7 mg., of minerals 40.68 mg., and the yield 31.7. Series XV receiving formula B+¼ (the arbitrary normal nitrogen supply) received increments of 12 mg. N and 44.12 mg. minerals and yielded 35.73.

The yields of the two series are not significantly different and the increments of nitrogen and minerals are essentially the same, although there is considerable difference in the two formulae.

Examining now the results from the McMurtrey formula × 3 (XXI) we observe that the increment of nitrogen is 47.1 mg., and of minerals 122.04, with a yield of 49.75. This yield is significantly higher than that of the normal McMurtrey formula and compares with the yield from Series XII, where the increments of nitrogen were 48 mg. (practically the same) and of minerals 44.12 mg. While the nitrogen of Series XII and XXI are the same, there is a distinct surplus of minerals in XXI as compared with XII. This would indicate that the quantity of available nitrogen had been the limiting factor regardless of the mineral content.

In Table 4 are given the ratios (in parts per million) between nitrogen and minerals for all series. An examination of these ratios will reveal several interesting features.

TABLE 4.—*Showing the ratio for each series between nitrogen and minerals.*

Series	Treatment	P.P.M.	Ratio N	Ratio M	Total concentration	Yield
I	McMurtrey	N=12 M=31	1	2.5	.0098	31.7
II	Normal A	N=0 M=46	0	46.	.0080	17.5
III	" A × 2	N=0 M=92	0	92.	.0160	16 67
IV	" A × 3	N=0 M=138	0	138.	.0240	11.45
V	" A × 4	N=0 M=184	0	184.	.0320	13.20
VI	" A × 6	N=0 M=276	0	276.	.0480	11.30
VII	" A × 8	N=0 M=368	0	368.	.0640	15.67
VIII	" A × 10	N=0 M=460	0	460.	.080	11.67
IX	" B	N=0 M=33	0	33.	.0062	19.9
X	" B × 3	N=0 M=99	0	99.	.0186	17.08
XI	" B × 6	N=0 M=198	0	198.	.0372	13.67
XII	" B + Normal N	N=38 M=33	1	.85	.0175	47.08
XIII	2B + 2N	N=76 M=66	1	.85	.0350	55.83
XIV	4B + 4N	N=152 M=132	1	.85	.0700	52.83
XV	Normal B + ¼N	N=9 M=33	1	3.6	.0090	35.73
XVI	" B + 2N	N=76 M=33	1	.43	.0288	27.50
XVII	2B + 4N	N=152 M=66	1	.43	.0576	30.20
XVIII	Normal B + 4N	N=152 M=33	1	.21	.0514	14.09
XIX	3B + 3N	N=114 M=99	1	.85	.0525	52.08
XX	McMurtrey × 2N	N=24 M=62	1	2.5	.0196	47.92
XXI	" × 3N	N=36 M=93	1	2.5	.0294	49.75

Taking Series XII, XIII, XIV and XIX it will be seen that the ratio of N to M is the same for all four, but that the concentrations range from .0175 to .0700. The highest yield was obtained from a concentration of .0350, which is, however, not significantly greater when probable error is considered. The evidence would certainly suggest, however, (1) that there was little to be gained by a concentration above .0350 and (2) that it is doubtful if a concentration as high as .0700 can be considered as above the optimal maximum.

Again, comparing Series XVI, XVII and XVIII we see that the ratio of N to M varies from 1 : .43 to 1 : .21, with concentrations from .0288 to .0576 and with a yield decreasing as the N to M ratio gets narrower, until it can be accepted as exerting a toxic influence. That this is not due to excess total salt concentration or total nitrogen is evidenced by comparing XVIII with XIV, both receiving the same weekly increments of nitrogen, with the highest yield coming from the highest total salt concentration. Another comparison will show that the excess of minerals over N may be over a very wide range before toxicity exists. Take I, XV, XX and XXI —the ratios for all four are rather close, roughly 1N to 3M, and the concentrations range from .0090 to .0294, with yields increasing as nitrogen increments and concentrations increase.

While the data suggest a wide range of excess of minerals over nitrogen before toxicity is apparent, it also indicates that even with total salt concentrations below the possible maximum the excess of nitrogen over minerals very soon reaches the danger point. In this direction the optimum ratio appears to be over a very narrow field, in the neighbourhood of 1 : 1.

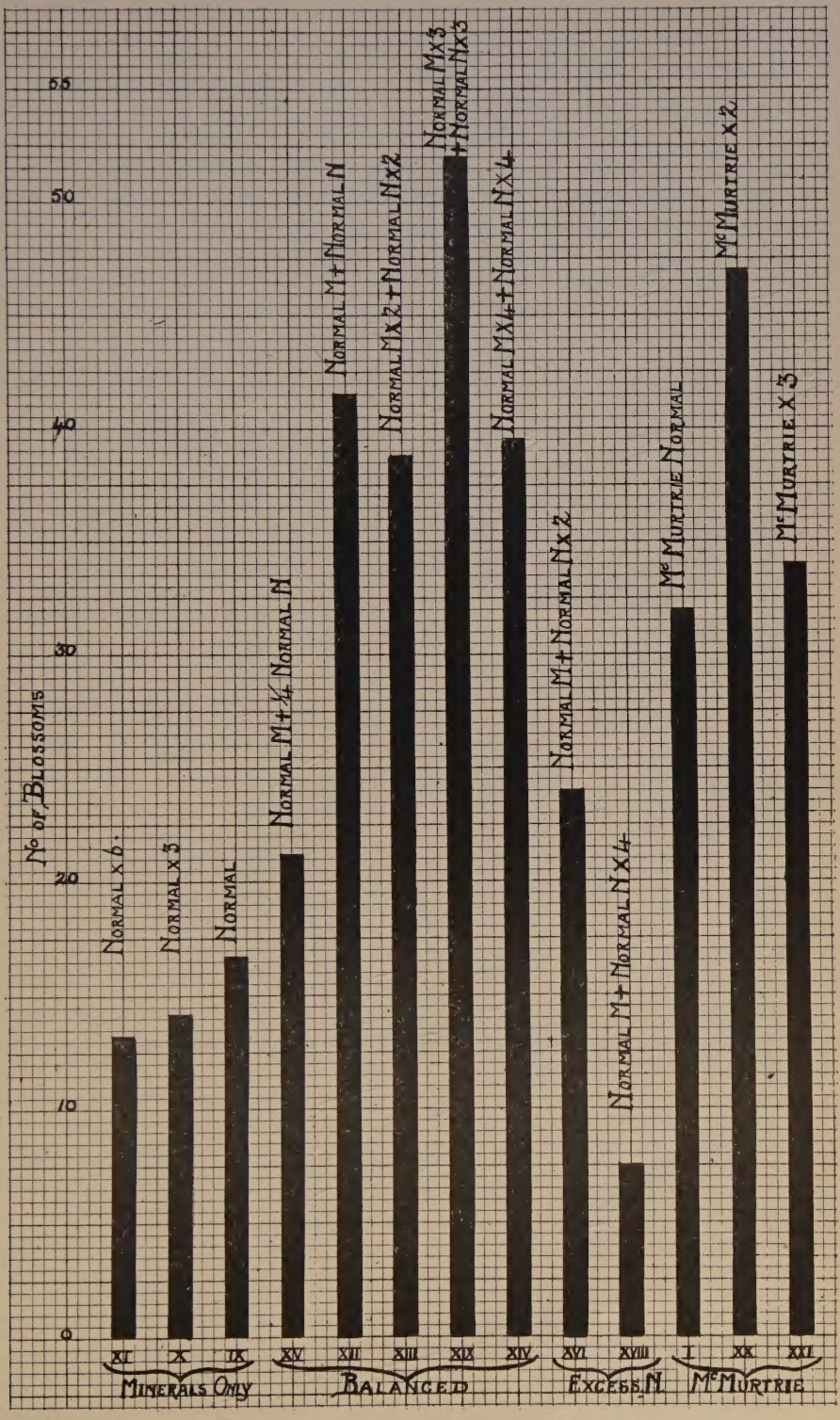
No. of Blossoms
0
10
20
30
40
50
55
Normal x 6
Normal x 3
Normal
Normal M + ¼ Normal N
Normal M + Normal N
Normal M x 2 + Normal N x 2
Normal M x 3 + Normal N x 3
Normal M x 4 + Normal N x 4
Normal M + Normal N x 2
Normal M + Normal N x 4
McMurtrie Normal
McMurtrie x 2
McMurtrie x 3
XI
X
IX
XV
XII
XIII
XIX
XIV
XVI
XVIII
I
XX
XXI
Minerals Only
Balanced
Excess N
McMurtrie

Figure 2

Quantitative Data from the Soil Group.

Table 5 gives the results from the soil series, which corroborate to a marked degree the results from pure sand. Without going into a great deal of detail it will be noticed (1) that the series without nitrogen were much inferior in production, (2) that the normal solution, Series XII, was little better, while twice the normal was decidedly superior, with four times normal easily the best. The next point of interest is Series XVI, where nitrogen was doubled, while minerals remained normal. The yield here was comparatively superior to Series XVI in sand. It must be remembered that there was no measure of the available minerals or nitrogen in the potting soil, which must have been considerable. The fact that an unbalanced solution for sand produced much better results in soil might indicate that the potting soil was originally lacking nitrogen in ratio to minerals.

Table 5.—*Summary of the results from the soil group.*

Series	Treatment	Yield	
I	McMurtrey Formula	22.11 ± 2.76	Full nutrient solution.
II	A (No N)	11.33 ± 1.41	Minerals only in varying concentrations.
III	A × 2	10.63 ± 1.32	
IV	A × 3	12.40 ± 1.55	
V	A × 4	13.00 ± 1.63	
VI	A × 6	8.75 ± 1.09	
VII	A × 8	12.14 ± 1.52	
VIII	A × 10	7.00 ± .87	
IX	B (No N)	13.77 ± 1.72	Minerals only in varying concentrations.
X	B × 3	10.55 ± 1.32	
XI	B × 6	13.55 ± 1.69	
XII	B + Normal N	17.38 ± 2.17	Nitrogen and minerals in varying ratios and concentrations.
XIII	2B + 2N	29.38 ± 3.67	
XIV	4B + 4N	52.59 ± 6.57	
XV	B + ¼N (Deficient N)	29.36 ± 3.67	
XVI	B + 2N	46.24 ± 5.78	
XVII	2B + 4N	31.57 ± 3.95	
XVIII	Not run		
XIX	3B + 3N	33.14 ± 4.14	
XX	McMurtrey Formula × 2	29.94 ± 3.74	
XXI	" " × 3	22.76 ± 2.84	

It will be noted that the probable error is higher than in the sand series. While the soil used was mixed as carefully as possible, there was evidence to indicate that some pots received much larger quantities of manure than others. This group, therefore, cannot be considered under as good control as the sand group.

It is furthermore of interest to observe that in such an unbalanced soil a properly balanced nutrient solution, if applied at sufficient concentration, e.g. Series XIV, can produce as good results as if the balance had been corrected by an optimum application of the deficient factor.

Influence of the Solutions on Set.

There was very little difference between the actual percentage of blossoms set among the different series. Each series appeared to have the ability to set about fifty to sixty per cent of the blossoms formed. What would have happened had a series had its food supply changed, say, in early spring is another question, but with a constant ration there seemed

little significant difference between any two series as to their ability to set the blossoms they had produced.

Production of Dry Weight.

At the end of the first growing season six plants from each series were lifted and dried to constant weight. Table 6 gives these results and Figure 2 shows them graphically. The graph bears a close resemblance to Figue 1, with two exceptions, which, owing to the small number of plants used, may be due to error. On the whole there is a high degree of correlation between number of blossoms produced and total dry weight of plant the fall before production.

Table 6.—*Absolute dry weight in grams of six strawberry plants from each of the sand series.*

Series	Entire Plant	Roots	Crown
I	31.835	24.76	7.075
II	19.454	16.80	2.654
III	14.149	13.265	.884
IV	16.79	15.03	1.76
V	16.79	15.03	1.76
VI	14.16	12.4	1.76
VII	18.56	16.8	1.76
VIII	11.48	9.72	1.76
IX	16.80	14.15	2.65
X	14.14	12.38	1.76
XI	13.26	10.61	2.65
XII	41.56	32.72	8.84
XIII	38.90	30.95	7.95
XIV	39.78	30.06	9.72
XV	21.21	17.68	3.53
XVI	23.87	20.34	3.53
XVII	28.29	22.99	5.30
XVIII	7.515	7.075	.44
XIX	52.17	38.02	14.15
XX	47.24	39.79	7.45
XXI	33.602	22.99	10.612

Summary.

(1) A study was made of the effect of nutrient solutions of different ratios of nitrogen and minerals upon strawberry plants in both pure sand and soil.

(2) The quantitative data showed the danger of excess of nitrogen over minerals, indicating that a ratio of 1 nitrogen to 1 minerals was about as close as the ratio could be brought with safety.

(3) On the other hand, excess of minerals over nitrogen, up to 1 nitrogen to 3½ minerals, did not appear to cause distress.

(4) A ratio of 1 nitrogen to .85 minerals appeared optimum.

(5) Total salt concentrations varied from .0090 to .0700 without materially affecting the results.

(6) None of the solutions showed any interpretive effect upon the set of the blossoms.

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ECONOMIC IMPORTANCE OF WIREWORMS AND FALSE WIREWORMS IN SASKATCHEWAN*

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In view of the obscurity and complexity of the wireworm problem, this discussion, although based on more than five years (1922-27) study as a major project of the Saskatoon laboratory, is in the nature of a preliminary or progress report. It is the first survey of the economic status of wireworms in Saskatchewan.

The average annual loss in this province, directly attributable to wireworms, at the present time ranks second only to that caused by the wheat-stem sawfly (*Cephus cinctus* Nort.) among insect pests. Moreover, a study of the situation leaves no doubt that this loss is steadily increasing, since the more important species concerned are typically associated with the characteristic crop system of the region, that is, with land under continuous cultivation for several years. Several species are involved, the prairie grain wireworm, *Ludius aereipennis tinctus* Lec., being of outstanding importance.

PRESENT ECONOMIC IMPORTANCE

Economic distribution.—Particular attention has been given to reports of damage and to the conditions existing in infested fields. During the five-year period nearly 800 reports have been received definitely recording important injury by wireworms in not less than 1000 fields. Some 160 of these fields have been visited, the detailed investigations extending into all parts of the province where serious wireworm damage has occurred; quantitative work was done in 31 representative fields, in four instances continuously throughout the five-year period. These records are charted on the map, Figure 1, each point representing recorded damage in at least one field in at least one year. The distribution and frequency of the dots represent with considerable accuracy both the distribution and intensity of existing infestations of economic importance.

The areas heavily infested by wireworms include, geographically, nearly all of the western two-thirds of the province. East of this, insofar as we have record, serious wireworm damage is not now general, although occurring in occasional fields or small districts. In the western area important general damage occurs year after year and involves all except the most resistant crops. On the contrary in the eastern section, important injury is recorded in the main only during years, or under conditions, exceptionally favourable to wireworm activity, or to crops which are

*Contribution from the Division of Field Crop and Garden Insects, Entomological Branch, Department of Agriculture for Canada, Ottawa.

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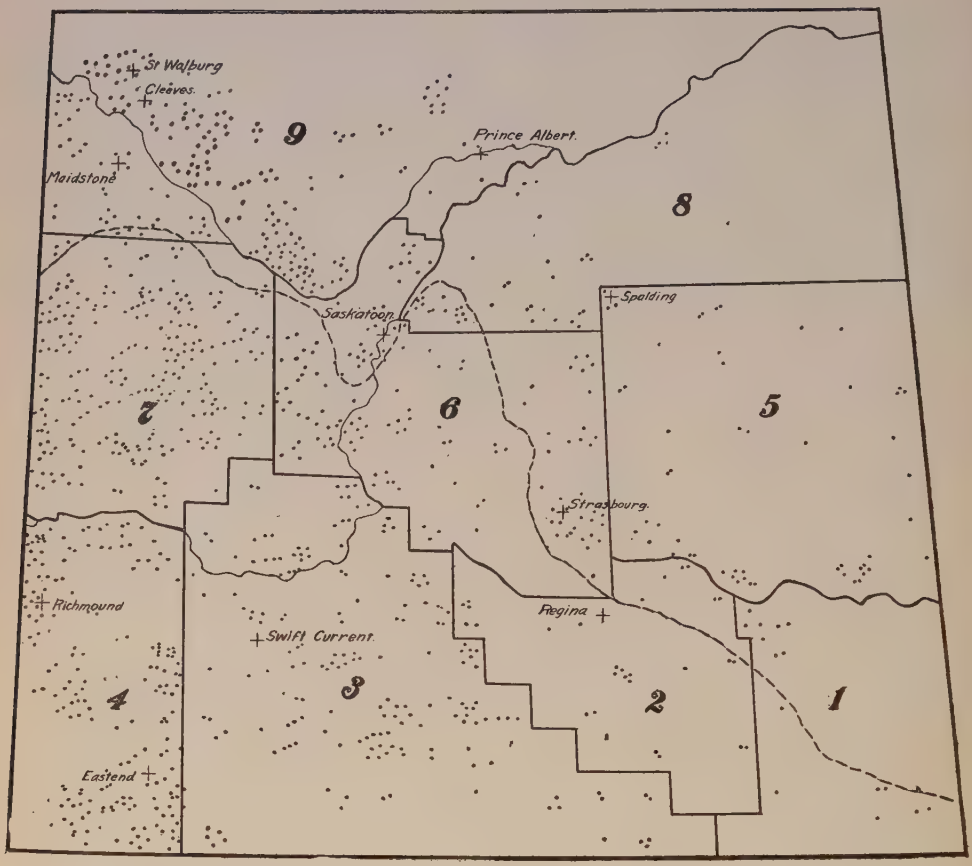

FIGURE 1.—Map of Saskatchewan (southern half*) showing distribution of recorded wireworm infestation.

particularly susceptible to injury. The line of demarkation between the two areas is neither regular in outline nor marked by any abrupt change in intensity of infestation. Furthermore, at the present time it appears to bear no exact relationship to the boundaries between the major original plant communities, a condition doubtless resulting in part from the admixture of species of different ecological characteristics.

Estimates of losses for 1926 and 1927—The above conception of distribution and intensity of wireworm infestation has been realized for several years, but not until 1926 could definite estimates of the losses resulting from wireworm work be arrived at with any accuracy. These estimates (Table 1) were made possible only through the co-operation of the Statistics Branch† of the Saskatchewan Department of Agriculture and

*Including all the area in which agriculture is being carried on to any extent. The divisions shown are those which are in use for crop statistical purposes; these crop districts vary greatly both as to proportion and total yields of the various crops. The dashed line represents the approximate boundary between the prairie and the main belt of poplar grove savanna.

†Grateful acknowledgment is made to F. H. Auld and to R. W. Neely, Acting Secretary of Statistics, of the Saskatchewan Department of Agriculture, for originating this valuable addition to the crop reporting service, and for making the results so freely available.

its large and well organized corps of experienced crop correspondents. The figures shown in Table 1 are based primarily upon the averaged percentage estimates given by the 572 crop correspondents who reported in 1926, and by 665 in 1927, but were checked, in each year, by information from some 500 independent observers, as well as by the field investigations in most of the affected districts.

Note that, in 1927, the estimated final crop loss in western and central districts averaged 2.51 per cent, as compared with 1.65 per cent in district 8 (northeastern), an average of 0.64 per cent in districts 5, 2, and 1 (east central, southeast central, and southeast), and an average of 1.86 per cent for the province as a whole.

TABLE 1.—*Estimated average reduction in yield*

Crop district number		Estimated average reduction in yield 1926	1927	Estimated total loss (net) 1926	1927
Eastern	1	0.05%	0.30%	$ 10,000	$ 50,000
	2	0.50%	0.75%	$ 150,000	$ 175,000
	5	0.40%	0.75%	$ 100,000	$ 190,000
	8	0.50%	1.65%	$ 90,000	$ 295,000
Central	3	2.00%	2.25%	$1,100,000	$1,110,000
	6	2.00%	2.00%	$ 540,000	$ 645,000
Western	4	5.00%	2.60%	$ 450,000	$ 550,000
	7	4.00%	3.20%	$ 660,000	$ 775,000
	9	3.00%	2.35%	$ 400,000	$ 355,000
	Province	1.50%	1.86%	$3,500,000	$4,145,000

These estimates undoubtedly include only the more obvious damage, since it is at present impossible for anyone to estimate the general effect of the partial and uniform thinning-out of crop stands (see subsequent discussion). Within this limitation, the actual values given above, of averaged estimates for the province and the crop districts, are probably very significant; certainly their comparative value, from year to year and from district to district, is very high. Taking the province as a whole, the values given for 1926 are believed to be fairly near the mean for recent years.

The estimates of losses, as expressed in dollars, are calculated from the standing-crop values, on the basis of the estimated percentage reduction in yields. They are affected not only by variations in the latter, but also by the condition of the crop and its value in the district and year in question. This point is well illustrated in the figures for crop district 4, where the percentage of damage in 1927 was scarcely half that of 1926, but since the crop value was more than doubled, the net loss in dollars in 1927 actually exceeded that of the previous year. The average percentage given, for any group of districts, has been corrected for these great differences in crop values in the several districts.

Extent of damage in individual fields.—Were these losses distributed uniformly over all fields of the area affected, their importance would be relatively small. Such, however, is not the case, the average being made up of heavy losses in many fields, moderate damage on a large number of farms and negligible, if any, injury on the remainder.

An instance (Fig. 2) of severe wireworm damage typical of conditions in many fields in this province annually, came under observation near Saskatoon in 1927. The crop was wheat, seeded relatively early in land which had been fallow the previous year. On some 80 acres the wheat was so completely destroyed that it was not necessary even to cultivate the area before re-seeding to oats. This late seeding was suitable only

for green feed, so that this portion of the crop was nearly a total loss (Fig. 2A). The wireworm population of this portion of the field was some 240,000 per acre. Close examination revealed the fact that wireworms were responsible for at least the greater part of the observed injury. The crop of wheat on the balance of the 200 acre field seemed fairly promising when given a casual examination "from the road." On closer inspection there were found, scattered through the field, numerous bare spots (Fig. 2B) up to nearly an acre in size and making up perhaps a third of the area, in which the stand of wheat had been completely destroyed, the bareness being obscured at a distance by the heavy green growth of weeds. Throughout a great part of the remaining area the stand had been severely thinned and greatly delayed, either as a direct result of partial injury, or from heavy stooling producing a rank growth of straw. This delay, under the conditions of the year, resulted in the virtual ruination of even this part of the crop by wheat stem rust, a condition therefore, in this instance, almost directly attributable to the earlier injury in the spring. The final yield of the portion of the field not totally destroyed averaged only 10 bushels per acre of low grade wheat, as compared with a yield of from 25 to 30 bushels of wheat of good grade, which was secured in comparable adjacent fields where wireworms were not numerous. The net loss in this single field in 1927 was estimated at four thousand dollars, i.e., in the absence of wireworm damage, an additional cash return of over five thousand dollars would have been secured at an additional expenditure for harvesting, threshing and hauling, of little more than one thousand dollars.

On two other farms which have come under observation, serious injury, such as that described above, has occurred yearly in most of the fields during each of the past several years, the wireworm infestations running as high as 40 per square foot and averaging 800,000 per acre over considerable portions of fields. In both instances, the farmers were seriously considering giving up otherwise excellent crop land.

The obscure nature of wireworm work, when a moderate infestation is distributed more or less uniformly through a field, is well known to entomologists. Only after careful search by trained observers can the exact extent of the injury be discovered. It has been found that, because of these facts, wireworm damage amounting to ten or fifteen per cent, or even more, of the crop yield in a field, is overlooked by most farmers, or is attributed to other causes. A striking example of this appeared in the 1926 investigations in a field at Saskatoon which has been kept under careful quantitative investigation annually since 1923. In 1926, following a poor fallow ploughed in midsummer of the previous year, wheat was seeded early and at a heavy rate. It was found that wireworms destroyed more than 80 per cent of the stand and reduced the final yield of wheat by at least one-third, possibly one-half. Yet the thinning out was relatively so uniform and was so obscured by heavy growth of wild oats and other weeds, that the owner did not realize either the extent or the cause of his loss.

FIGURE 2.—Field of wheat near Saskatoon, Sask., showing serious injury by wireworms; (left) re-seeded area, looking toward the less severely damaged portion; (right) edge of a large spot, bare of crop, within the latter. (Photographs, Aug. 20, 1927). For further explanation see text.

In view of well authenticated instances such as this, it is felt that the general estimates presented above, while as accurate as present knowledge permits, probably are too conservative, even without taking into consideration the perhaps equally important cumulative effect of the less obvious injury.

Recognition of wireworm damage—From the preceding discussion, the extent to which the wireworm problem has been complicated, particularly in field crops, by the hidden nature of wireworm work, and by the consequent difficulty for either laymen or entomologists accurately to gauge the full extent of the injury which this pest causes, has been inferred.

It has been found that unless the search is made during the comparatively short period of their maximum activity in the spring, the wireworms themselves will be missed almost entirely in superficial examination, and the characteristic evidences of plant injury will no longer be visible. The tendency then is either to overlook the damage, or to attribute it to cutworms, to the weather, or to unknown causes, thus both minimizing the importance of the true cause and rendering the employment of suitable preventative measures a matter of chance.

Fortunately, with a little experience, a considerable degree of accuracy in recognition of the injury is possible. Areas of poor crop stand usually can only be located by going through the field. In each area found, a careful search should be made, in the spring soon after the grain is up, digging up a foot of row here and there to examine each seed and plant.

The first, and most important, injury is to the seed. The centre is eaten out, leaving only the characteristic empty husk; or the seedling may be destroyed just as it issues from the grain; in either case, no plant is produced. A little later, the young plants are attacked, especially in moist soil. The wireworm bores into the stem, usually just above the seed, and eats out the centre of the stem for as much as an inch or more, leaving the withering tops, which, characteristically, are attached to the roots by portions of the sheath; typically, the central shoot withers much more rapidly than the outside leaves. Such plants seldom recover enough to produce a head, although in wet weather secondary shoots are frequently put out; those most seriously damaged soon dry up and are blown away. During this search, if it is made before the soil becomes dry and hot, the wireworms themselves will be easily found, in some numbers, near injured plants, or approaching adjacent undamaged ones.

It may be noted:—Wireworms have hard, wiry, flattened bodies, which are usually a bright straw-yellow in colour, and shiny as though varnished; have only three pairs of legs; usually very sluggish in movement. Many sizes occur together, the largest ones common in Saskatchewan fields being a little more than an inch long, and of the size of a flattened stem of wheat. The false wireworms are very similar, but are usually brown in colour and much more active with certain other less obvious differences. Both contrast strongly with the soft, round-bodied, dull-coloured, sixteen-legged cutworms, which are about one and one-half inches long and as thick as a pencil when full grown, and have the habit of rolling up into a ring when disturbed. In contrast also, plants attacked by cutworms are usually completely severed at or near the surface of the soil, and the tops of the young plants are often entirely consumed at once.

This distinction is very important, both because of its effect on the measures employed for immediate reduction of damage, and because (as noted later) wireworm infestations in the prairies usually change very slowly, whereas a cutworm infestation in a field one year does not predicate a similar condition there the following year.

Relation to methods of cultivation.—The outstanding characteristics of the problem in Saskatchewan are, (1) the occurrence of the most severe damage by wireworms, almost invariably, to the summer-fallow crop and (2) the association of the heavier wireworm infestations, on the whole, with fields which have been under cultivation continuously for many years. These distinctive features, which forced their recognition in the first year of investigation, are well brought out in a letter dated June 27, 1924, from P. H. Ferguson, at that time with the Saskatchewan Department of Agriculture as District Representative, with whom the writer had the pleasure, in 1923, of making a brief survey of one of the important areas of infestation:— "In the course of my investigations I have found that in every case the soft mellow summer-fallow was affected. Stubble land lying next to the fallow was not touched. Neither was poorly fallowed land which had grown a heavy crop of weeds last year affected . . . I found that there was very little sod in these fields and that they had been cultivated for a number of years."

Of these characteristics, the first is the more typical, since it appears to be equally true of each of the several economic species so far encountered, and of every part of the infested area without regard to the frequency with which fallowing is employed. This special severity of damage to the first crop after the fallow year seems largely connected with soil moisture conditions favouring wireworm activity for a longer period than in other fields in the same year, and not upon changes in the wireworm population.* The facts, that fallow fields are, as a rule, seeded earliest, and that the crop is usually wheat, which is rather susceptible to damage by wireworms, are also of importance; it is possible, too, that the larvae are more voracious after a year of decreased supply of growing food.

The economic significance of this special injury to the summer-fallow wheat is clear, when it is realized that more than one-fifth of all the land under cultivation in Saskatchewan is fallow each year, and that more than 40 per cent of the acreage, and an even higher proportion of the yield, of wheat, is on land fallowed the previous season. In much of the area where wireworms are a serious problem, fallowing occupies an even greater part in the system of cultivation. The summer-fallow wheat is not only the most valuable cash crop, but often also is the only reliable money-making crop during unfavourable seasons.

The occurrence of the heavier wireworm infestation on the whole in fields which have been under cultivation for from several to many years, during which time no crop of grass has been grown, is similar to the con-

*This concept, which does not appear to have been brought out previously in the literature, appears strongly supported by the quantitative findings up to the present.

ditions reported in Washington,* but differs from that which has usually been considered typical of wireworm infestations. In Saskatchewan, at least one important species is usually found in connection with sod, but the majority, including the chief species, seem to be favoured by the conditions found in the production of grain crops and the use of the summer-fallow. Numerous instances are at hand, however, where severe injury has occurred in fields immediately after the turning of the native sod, or when seeded grass meadows or fields temporarily abandoned are again broken up. Indeed, in some portions of the province and in certain kinds of soil, this may be regarded as the typical condition, although here also there is a strong tendency for the wireworm infestations to persist or to become re-established after some years of cultivation.

Another feature is the considerable duration of wireworm infestations, when well established. This results, in part, from the fact that several years are required for the completion of the life-cycle of most wireworm species, and that there exist no proved or practical means of their immediate destruction in large fields; it is true in some measure wherever wireworms are troublesome. It is particularly important in Saskatchewan, since many of the species have shown themselves able to maintain, or even increase their numbers, under conditions of thorough cultivation.

One interesting instance, suggesting an important effect of wild mustard in reducing wireworm infestation, has come under observation. In a large area of rich heavy soil south of Regina, wireworms caused extensive damage at the time the native sod was broken and for some years after. Some years ago wild mustard (*Sinapis arvensis* L.) became established as the most troublesome weed of the district, and almost coincidentally the wireworm has ceased to be a problem there. In view of the fact that we have not yet been able to follow through the factors involved in this change in particular fields, in this district, no definite statement can be made as to whether or not this is a case of cause and effect. The circumstances are very suggestive, however, in view of the use of white mustard in England† for its directly adverse effect on wireworms, as well as for its resistance to injury by them.

Relation to weather and soil conditions.—The preceding discussion has brought out the noteworthy facts:—First, that there is considerable variation from year to year, both in the total wireworm damage in the province, and in the relative destructiveness in the different sections; second, that the variation is even more marked in an individual field in different years, and, in any season, between comparable fields of similar infestation, the damage being especially severe to the first crop after fallow.

Unpublished investigations‡ show that these variations are largely connected (within the normal range and seasonal sequence of temperature

*Hyslop, J.A. Wireworms attacking cereal and forage crops; U.S. Dept. Agric. Bull. 156, 1915; *Ludius (Corymbites) inflatus* Say, and *noxius* Hyslop.

†vide Fryer, J.G.; Gardeners' Chronicle, London, No. 1676, 1919 (as reported in R. A. E. VII, A, 208, 1919).

‡The data, upon which the following statements are based, resulting from rather extensive, quantitative, field and laboratory studies, will be brought together in a subsequent paper.

conditions) with differences in the soil moisture conditions:—First, of spring and early summer, as affecting wireworm activity and crop recovery; second, of late summer, as largely determining changes in infestation. Both meteorological and edaphic factors,—especially precipitation, type of soil, drainage, and vegetation cover,—are of importance. The moisture conditions of the surface layer of soil, during the spring and very early summer, largely determine the length of period of active feeding upon seed and stem, and, hence, the number of plants damaged by each wireworm. As soon as the upper soil becomes warm and moderately dry, the wireworms go deeper and feed chiefly upon the roots, where they can cause relatively but slight damage, and this general movement may take place very early in May or be delayed until late in July. The available soil moisture content, especially of the deeper layers, later conditions the extent of recovery of damaged grain plants, and the amount of stooling of the uninjured ones. Under Saskatchewan conditions, maximum wireworm injury to grain, in a region, may be expected when the rains are frequent, during May and much of June, but of small amount, followed by dry weather, with no moisture reserve in the deeper soil, carried over from winter or early spring. Differences of several hundred per cent between the minimum and maximum damage have been observed, all conditions other than moisture apparently having been equal. The exact effect of precipitation conditions, as between adjacent fields or areas, varies markedly with the immediate environmental factors, being most marked in medium to light sandy loam soils.

It has been found also that there may be considerable, though usually slow, changes of infestation, depending particularly upon soil moisture conditions during a critical period in late summer. An increase in wireworm population usually follows a year of high precipitation during this period, while an especially dry summer results in a decrease. The latter effect is most marked in fields which have that season produced a heavy crop, that, after exhausting the soil moisture to a marked degree, is cut just before the period most critical for the wireworms, thus exposing the latter at once to the maximum soil temperature and minimum soil moisture. The quantitative data, as secured to date, give no evidence that the wireworm population can be materially reduced during the summer-fallow year, by any methods which will at the same time secure the main purposes of the practice, namely, moisture conservation and weed destruction. It may, however, be possible in dry seasons to limit the increase in population which often results from fallowing.

Potential Importance

A further marked increase in the importance of wireworms in Saskatchewan would be anticipated from the facts which have been presented. In examining the data, due allowance must be made for the normal fluctuations in amount of damage, as the result of variations in weather and other controlling factors, as well as for the increased attention to injury of this kind, now being paid by farmers, due to recent publicity given the wireworm problem. The fact of a gradual but steady increase is amply substantiated:

(1) by a comparison between the relatively slight amount of loss recorded in the early days of prairie agriculture and that occurring at present; (2) by the many authentic reports received annually, recording important wireworm damage observed for the first time in fields of moderately long standing in cultivation, and increased damage in other fields which have been cropped for a longer average period; (3) by the discovery, arising from reports, of important entirely new areas of infestation in districts of comparatively recent settlement; (4) by the fact that new areas subject to severe infestation are still being settled, while in addition a considerable acreage of virgin land is being brought under cultivation annually in the older districts, thus providing many new fields in which, under present farm practices, important wireworm losses would be expected in due course. The extent to which this increase will take place cannot be predicted, but it is quite within the bounds of probability that the present annual losses from this pest may be doubled or trebled in due course, provided that no adequate remedial or preventive measures are put into operation by those affected.

Discussion by Species

Fortunately the larvae of most of the species encountered are fairly readily and accurately separable, by specialists, in the field by examination with a hand lens, after the morphology has once been carefully studied under higher magnification. During the course of the investigations, all of the larvae, amounting to several thousand, taken in the fields visited, have been examined and separated into specific groups based upon these morphological studies. The identities of these specific groups have been decided in most instances by subsequent rearing to the adult stage, but in a few cases have not yet been definitely settled. All of the species are native ones.

Ludius aereipennis tinctus Leconte, the prairie grain wireworm* is responsible for at least half, possibly two-thirds of the total crop injury by wireworms in Saskatchewan at the present time. It is present in important numbers in virtually all of the infested fields which have been examined, and is the only species of any consequence in a considerable proportion of the fields where severe losses are occurring annually. Its economic range extends throughout the present infested area, but its importance relative to other species, appears to be somewhat less in the savanna belt than in the more open country. Extensive quantitative soil sampling has shown that, while this species is able to maintain itself in a wide variety of habitats, its optimum,—that is, the conditions under which it reaches

*The common name is that adopted by the American Association of Economic Entomologists. (See Jour. Econ. Ent., 20, No. 6, pp. 838 and 839, Dec., 1927).

The use of the trinomial, the more definitely to designate this common wireworm of the Prairie Provinces, has been decided upon after consultation with W. J. Brown, of the Entomological Branch, Ottawa. According to both Dr. E. C. Van Dyke and P. J. Darlington (personal communication to Mr. Brown), the small black adults of the prairie belong to, or are a form closely related to, *tinctus Leconte*, which is placed by them as a western form of the variable species *aereipennis* Kirby, of which the typical form is found in the East. The form met with on the prairies appears to be distinct ecologically, as well as geographically and in appearance, intergrading only at the borders of the region. This usage is also in line with that which has been employed by J. A. Hyslop. (In Leng's Check List of Coleoptera, *tinctus* Lec. is placed as a synonym of *elegans* (Kirby)).

maximum numbers,— among native situations, is found in associations of the bunch grass type. This is particularly true in districts of heavy soil, especially of the kind known as "loose-top".* In a large territory in west central Saskatchewan (and in the Drumheller district in Alberta) where these two conditions combine, severe wireworm damage occurs, characteristically, during the first year or two after the breaking of the native sod which approaches the bunch grass type. In two representative fields having this history, the larval population of this species the year after first ploughing was found to range from 160,000 to 400,000 per acre. Emphasizing the same point are observations of the increase of this wireworm in fields seeded to western rye grass (*Agropyron tenerum* Vasey), a "tame" grass of bunching habit. Heavy infestations in true prairie sod which for some years previous had not been disturbed either by fire or grazing, have been studied by the writer.†

Notwithstanding these varied habitats, *Ludius tinctus* in Western Canada is typically the outstanding example among our species of the association, described in a previous section, with fields of long standing in a straight grain rotation. Populations of this species as high as 600,000 per acre have been found in considerable portions of heavily infested fields of this type, where no grass has been grown for many years, and where practically no vestige of weed grasses can be found. An interesting phenomenon in fields where this insect caused considerable losses to crops during the first year or two after the breaking up of the virgin sod, is the apparent marked decrease in numbers, followed by the slow rise again to infestations of economic importance, this rise evidently taking place more slowly in the very heavy than in fairly light soils. In the absence of quantitative work covering a sufficient number of years no well-founded explanation of this can be given.

Not only in point of numbers and in its evident powers of resistance to unfavourable conditions, is the prairie grain wireworm dangerous, but also because of its long life cycle, its relatively large size and particularly because of its habits of feeding and its activity, which enable it to cause more damage per larva, apparently, than any other wireworm encountered in Saskatchewan.

Cryptohypnus nocturnus (Eschscholtz), chiefly race *bicolor* (Esch.), is a sod-infesting species of the kind, until recently, considered typical of pests in this family. With one exception, we have taken it, in numbers of importance, only in immediate or very recent association: with sod; with scattered patches of persistent weed grasses, particularly couch grass (*Agropyron repens* (L.) Beauv.), sweet grass (*Torresia odorata* (L.) Hitchc.) or wild barley (*Hordeum jubatum* L.); or with remnants of cultivated grasses (western rye grass or brome, *Bromus inermis* Leyss).

*A. H. Joel, Professor of Soils at the University of Saskatchewan, kindly gives the information that this soil has very high proportions of silt and clay, but is made friable by a high lime content which, under the climatic condtions of the region, has not been leached from the upper soil layers.

†Dr. J. Fletcher on page 212 in his Report of the Entomologist and Botanist for 1904, Dominion of Canada, Dept. of Agriculture, makes a similar record (this species probably being involved).

On several occasions this wireworm has been found of outstanding importance immediately after the re-ploughing of fields which have been left idle for some years, during which time there has been a heavy growth of wild barley and other weeds. *C. nocturnus* has seldom been found in anything approaching pure infestations, but usually with a large admixture of other species particularly the prairie grain wireworm. In these latter instances, the independence of *L. tinctus* from, and the dependence of *C. nocturnus* upon the grass association, is often strikingly brought out by their mode of distribution in a field. *C. nocturnus* has been found in nearly all parts of the infested region and is responsible for perhaps one-fifth or more of the damage at the present time. It is believed that its true importance may not have been fully realized in the past, both because of the superficially rather close resemblance of its larvae to those of similar size of *L. tinctus,* and also because the larval size and habits are such as to cause it to be largely overlooked unless strictly quantitative methods are used in the field examinations for wireworms. In one instance, for example, somewhat casual examination indicated an infestation almost solely of *L. tinctus,* while quantitative sampling revealed this species and *C. nocturnus* to be present in almost equal numbers, the former being at the time (July 1927) still largely near the surface, while the latter had already burrowed to a depth of several inches. (This was the field described above, Fig. 2A).

Limonius pectoralis, Lec. was first encountered in 1926. It is evidently distributed through a large area of the savanna belt in northern Saskatchewan. Economic infestations of this species, both mixed and almost unmixed, have been investigated at Maidstone, Cleeves and St. Walburg. This species, in common with several others of the genus, appears to be definitely associated with deep rich loam soils, and somewhat low-lying but not waterlogged spots. In part, this may arise from the fact that the species seems definitely connected in native conditions with the snowberry (*Symphoricarpos*) thicket margin plant community. It is evidently able to thrive in a grassless rotation and, hence, is potentially of greater importance, especially should truck farming become common in this district. Its powers of destruction to grain are by no means as great as in the case of the two species discussed above.

Ludius virens (Schrank) has been found of primary importance in one field near Spalding, in 1927. This is in a district in which important infestations by wireworms have only recently been recorded.

Aeolus dorsalis (Say) (*Drasterius elegans** Auct.) has been found in rather large numbers in two fields in crop district 4, as well as in smaller numbers in several fields over a wider area; in both the first two instances, it was in conjunction with a considerable infestation of *L. tinctus.* The observations made, indicated that it would be a crop pest of some importance, but were not sufficient to settle this point definitely, in view of the

*According to Leng's Catalogue of Coleoptera the name *Drasterius* (Auct. nec. Esch.) *elegans* (Auct. nec Fab.) has been cited in error for *Aeolus dorsalis* (Say). The larva figured, under the former name, in various texts (after Forbes) evidently does not belong to the subfamily Elaterinae in which Leng places *Drasterius* Esch.

statements of Hyslop (*loc.cit.* p. 23) with reference to its predaceous habits under many circumstances. Probably, as observed with several other of the local species, it may act in either way, though its greater activity may predicate a more pronounced tendency towards the predatory habit in it than in the others.

Agriotini?, spp.—Larvae of two species have been taken in cultivated fields, a rather small species of considerable importance in southwest Saskatchewan, and a much larger form in small numbers in the north, both of them, so far, always in association with other wireworms. They have not been reared to adults. The larvae have been examined by Dr. Adam G. Böving, who states that they belong in the Elaterinae and probably in the Agriotini, but apparently are not identical with any species the larvae of which are known; they are excluded from the genus *Agriotes* Esch., as at present understood, by the absence of the pair of deep spiracle-like impressions on the 9th abdominal segment.

Lesser species.—Three other wireworms have been taken in cultivated fields but not in numbers of much importance. These are *Hypnoidus dubius* Horn, *Ludius limoniiformis* (Horn) and an undetermined species, *Ludius ?* sp. The two last-named are both associated with thicket margins.

False Wireworms.—The false wireworms in Saskatchewan reach their greatest abundance in the more arid parts in the southwest of the province, but extend also in small numbers as far as the outer margin of the savanna belt, and slightly within it. The group as a whole is not yet of great importance here, although probably having greater potentialities for the future. Only *Eleodes extricata* (Say)* has been found of any real economic standing in Saskatchewan to date. In 1923 it occurred in considerable numbers, mixed with wireworms and cutworms, in one field at Strasbourg, which is situated in rather heavily wooded country. Except for this record the species has only been encountered in districts of mixed prairie or plains. The larvae are troublesome nearly every year in the Richmound district, and in 1927 a heavily infested field was found near Eastend. Larvae of *E. tricostata* (Say) have been taken in small numbers in several situations in Saskatchewan, chiefly in gardens, but have been of no real importance. The adults of *E. hispilabris* (Say) are the most common and conspicuous of this genus throughout most of the area mentioned, but its larvae have been encountered only rarely; we have no record of serious infestations in Saskatchewan by this false wireworm. This is in marked contrast to its standing elsewhere. Several adults of *E. obsoleta* (Say) and a single adult of *E. opaca* (Say) have been taken.

Summary

A detailed appraisal of the present situation in Saskatchewan of damage by wireworms and false wireworms in general, the future potentialities insofar as they can be gauged and the economic status of the several species

*The Saskatchewan adults of this species are all considerably smaller than the lower limits given for the form *convexicollis* Blaisdell, which is the smallest form of this species which he describes. (U.S. National Museum Bull. 63).

involved, is presented (without discussion of remedies) as a preliminary report based upon more than five years' study, much of it quantitative.

Heavy infestations occur fairly generally throughout the western two-thirds of the province, and in a number of fields in eastern districts. It is established, by detailed estimates, that net losses, attributable to the more obvious wireworm damage, average more than three million dollars annually at the present time, and are steadily increasing. Two instances, typical of very heavy and of moderate damage in fields, are described in detail, as well as means of accurate recognition of crop injury by this pest.

The distinctive features of the problem in Western Canada are (1) the occurrence of the most severe damage by wireworms, almost invariably, to the summer-fallow crop; (2) association of the heavier wireworm infestations, on the whole, with fields cultivated continuously for many years; (3) the long duration, under most conditions, of serious infestations when once established. Some important relationships between soil moisture conditions, during certain critical periods, and rate of wireworm injury, extent of crop recovery, and fluctuations in wireworm populations, are stated.

The ten wireworm species taken in cultivated fields, and the five false wireworm species which have been encountered in the province, are listed, and the more important ones briefly discussed. The prairie grain wireworm (*Ludius aereipennis tinctus* Lec.) which is outstanding at present, also appears to have the greatest potentialities for the future; it is independant of grass, although frequently abundant in sod. *Cryptohypnus nocturnus* (Esch.) is typically associated with grass. Other important species are *Limonius pectoralis* Lec., *Ludius virens* (Schr.) *Aeolus dorsalis* (Say), a species of Agriotini, and *Eleodes extricata convexicollis* Blais.

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Heterodera punctata n. sp. A NEMATODE PARASITIC ON WHEAT ROOTS FROM SASKATCHEWAN.

GERALD THORNE*

[Received for publication May 2, 1928]

In August, 1926, Mr. R. C. Russell of the Dominion Laboratory of Plant Pathology, Saskatchewan, kindly sent the writer some wheat roots which he had found to be infested with nematodes (*5*). When collected this material consisted of the white females attached to the roots but after drying in transit all had been converted into brown cysts in which the eggs contained fully developed larvae. A second collection consisting of young wheat plants with the soil surrounding the roots was received in June, 1927, and from this a complete series of males and females in all stages of development and a large number of empty brown cysts were secured.

Heterodera schachtii, a serious parasite of the sugar-beet, has frequently been reported as attacking wheat in Europe. Kuhn (*2,* p. 50) first reported it as attacking wheat in Germany and Nilsson-Ehle (*4,* p. 4) shows a photograph of infested winter wheat roots and reports it as severely infesting both winter and spring wheat. Marcinowski (*3,* p. 174) lists wheat as a host plant while Baunacke (*1,* p. 186) and other investigators mention it on wheat or cereals but give no definite descriptions.

All of these reports apparently indicate that the form of *Heterodera schachtii* found attacking wheat in Europe is identical to that found on the sugar-beet. However, when the specimens from Canada are compared to specimens of *H. schachtii* from sugar-beets grown in Europe and America they are found to have certain morphological differences that are of sufficient importance to justify the establishing of a new species.

Heterodera punctata n. sp.

Diagnosis:—Since *Heterodera schachtii* is the only other known species of the genus the following comparative table will best give the differentiating characters:

Heterodera punctata	*Heterodera schachtii*
1. Female body terminus rounded, body "pear-shaped."	1. Female terminus with caudal projection, body "lemon-shaped".
2. Female cuticle punctate.	2. Female cuticle not punctate.
3. Average length of female .52 mm.	3. Average length of female .8 mm.
4. Average egg content 78.	4. Average egg content 280.

The complete description is as follows:—

Larvae: Length, .35—.47 mm., esophagus 17%—22% of length. Cuticle marked by coarse striae that are interrupted on the lateral fields by two wings appearing as bright refractive lines. Frequently the borders of the wing area also present refractive lines similar to the wings. Anteriorly the

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body tapers gradually to a point opposite the base of the spear where it becomes more convex conoid and narrows to the distinctly set off lip region. There are six thoroughly amalgamated lips that are supported by a framework similar to that figured for the adult male (Figs. 12 & 13). The central, tubular portion of the labial framework forms a vestibule leading to the pharynx and serves as a guiding ring for the spear. The spear is two and one-half times as long as the width of the lip region and bears three large basal bulbs that make it almost one-third as wide as the head at this point. In general the spear closely resembles that of the male (Fig. 11). From the base of the spear a short slender tube extends back a distance about equal to the diameter of one of the basal bulbs of the spear. Here it becomes furcate—one branch forming the slender tube of the esophagus, the other leading to the glands in which, as Dr. Cobb has determined, the larva secretes the fluid which is injected through the spear into the plant root, breaks down the cells and forms an opening through which the larva enters the root tissues.

The slender tube of the esophagus leads back to the spherical median bulb which is half as wide as the neck at that point. This bulb contains a distinct cutinous valvular apparatus. The nerve ring encircles the esophagus just back of the bulb but is difficult to observe. The excretory pore is located about opposite the nerve ring and from it the distinct renette tube leads back toward the renette gland. However this gland is obscure and has not been seen by the writer. There seems to be no definite point where the esophagus leaves off and the intestine begins. The intestine is coarsely granular and completely fills the body cavity. The rectum and anus are usually almost invisible. The body ends in an elongate conoid, pointed terminus.

There are no visible differences between the males and females while in the larval form but soon after entering the root and feeding they become distinctly differentiated.

Female. The very young females and males are similar in form (Figs. 2 & 8) but can be distinguished by the developing spicula of the male and the huge development of the submedian salivary gland of the female. Doubtless this gland development is in preparation for the demands to be made upon it during the development of the female body and reproductive system. The ovaries appear early in the development and are coiled about the intestine in long slender lines (see Figs. 3 and 4). Fertilization takes place when the female reaches the pear-shaped form and the spermatozooa frequently can be seen in the uterus working their way upward toward the ovary. The lower portion of the uterus appears to be a sort of enlarged spermatheca into which the spermatozooa are deposited. Apparently there are two ovaries which lead from spermatheca. The vulva is a small, circular, slightly depressed opening (Figs. 3, 4 and 5). The extreme development of the intestine is a conspicuous feature as it completely fills the body cavity until the female is mature and doubtless acts as a reserve supply for food and energy when the eggs begin to develop. There is little change in the spear and esophagus but they are gradually pressed forward by the developing intestine and ovaries until they lose their identity. The lip region undergoes a remarkable transformation. The six lips are much more distinctly divided than those

of the larva and male and in addition a peculiar disc-shaped development appears about the mouth (Fig. 7). The distended cuticle is distinctly striated and these striae are resolvable into rows of dot-like marking that have the appearance of being minute pores. That these may be pores seems possible for the entire body of the female becomes covered with a silvery white, crystalline substance that perhaps is secreted through them. This crystalline body covering is not illustrated in any of the figures. There is a possibility that this is of the same material as a white gelatinous mass that collects about the anus and vulva. A similar mass is found on the females of *Heterodera schachtii* and into it the females often deposit part of their eggs. However *H. punctata* has not been observed to deposit eggs in this manner; in fact the small size of the vulva seems to preclude any possibility of their being deposited.

At maturity the female dies and her body becomes a protecting sac or cyst for the eggs with which she is filled. Each egg contains a fully developed larva (Fig. 5) which remains in the cyst until favorable conditions cause them to hatch. The cyst figured is of typical form but others are found that range from a form more elongate than this to those that are almost spherical. The large number of brown cysts found in the June collection contained no eggs with larvae, indicating that they had hatched as soon as favorable temperature and moisture conditions arrived and the young wheat roots were growing. The presence of favorable host plants doubtless acts as a stimulant to the larvae much the same as they do in *Heterodera schachtii*. If no host plants are grown in the soil some of the larvae may be expected to lie dormant for several years.

Male. In its development from the larval form the male follows a course very different to that of the female. After the first moult the body begins to grow in length and becomes looped within the cuticle (Figs. 9 and 10). When mature the male is an active slender nematode .9 mm. to 1.3 mm. in length and about one fiftieth as wide as long. There are two wings appearing as bright refractive lines and the borders of the area often are so prominent that there appears to be four wings. The striae of the outer cuticle are duplex on the subcuticle (Fig. 14). These inner striations are made up of rows of refractive dots. The details of the head and lip region are shown in Figures 11, 12 and 13. The esophagus occupies 14% of the body length. The submedian salivary gland is a conspicuous feature and crowds the anterior end of the intestine to one side. The single testis extends about half the length of the body and the vas deferens often contains dozens of amoebiform granular spermatozooa about one-sixth as wide as the body. The spicula are slightly arcuate and of large size (Fig. 14). On favorable specimens a pair of pores can be seen near the terminus and doubtless these are the phasmids.

Control Methods

No information is available concerning the host plants of *Heterodera punctata* and until such information is secured it will not be possible to plan the proper crop rotations that have been found necessary in the control of

similar plant infesting nematodes. Considering that this pest is found in fields that have been under cultivation only a short time it is evident that it must be a native parasite of some indigenous plant or plants. From the fact that it has selected wheat as a host it seems probable that one or more of the grasses will be found the original host.

Bureau of Plant Industry,
United States Department of Agriculture,
Washington, D.C.

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EXPLANATION OF PLATE I.

Stages in life history of *Heterodera punctata* n. sp.

1. Larva. 2. Female after first moult of larvae. 3. Female in flask form. 4. Immature female that has recently been fertilized. The amoebiform, granular Spermatozooa can be seen in the uterus. 5. Brown cyst filled with eggs containing fully developed larvae. 6. Punctate marking of the female cuticle. 7. Lip region of female. 8. Young male after first moult. 9. An intermediate stage in the development of the male. 10. A mature male ready to moult for the last time. 11. Head of male. 12. Lip region of male showing a lateral view of the framework of the lips. 13. Lip region of male showing face view of framework, papillae and amphids (?). 14. Lateral view of male tail showing wings, spicula, dot-like marking of the subcuticle and phasmids. 15. Ventral view of terminus of male showing tips of the spicula and phasmids.

KEY TO ABBREVIATIONS USED ON PLATE I.

al	wing	on	spear
amph	amphid	ov	ovary
cut	cuticle	p ex	excretory pore
disc	disc	pct	punctations
frm	framework	phas	phasmids
gl sal subm.	submedian salivary gland	ppl	papillae
grn int	granules of intestine	sp	spicula
int	intestine	spm	spermatozooa
lb	lip or labial	subcut	subcuticle
lrv	larva	tst	testis
nrv r	nerve ring	ut	uterus
oe	oesophagus	vlv	vulva

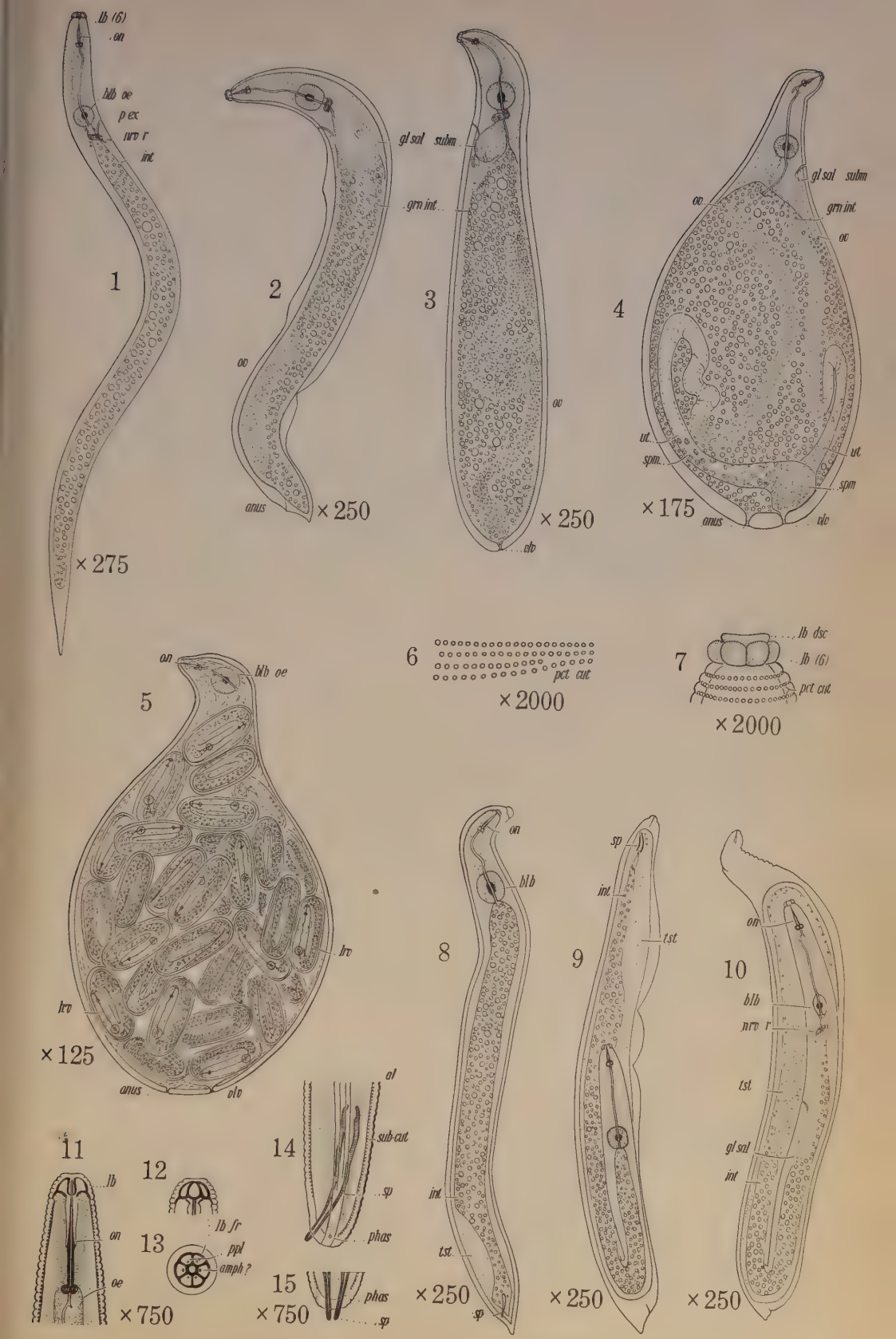
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PLATE I

THE REACTION OF WHEAT PLANTS AT TWO STAGES OF GROWTH TO STEM RUST.

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The work reviewed in this paper has been carried on with the aid of grants from the National Research Council of Canada and constitutes a part of the genetical study of rust resistance and the program for breeding desirable rust-resistant wheat, for which the grants were given. The first year's work was presented to the Grain Rust Committee of the National Research Council on February 15, 1927, and the completed report was submitted to the Council on September 20, 1927. The manuscript was held over for publication until after the next meeting of the Grain Rust Committee, on April 13, 1928, at which the completed report was given.

The problem of breeding wheat for resistance to stem rust, *Puccinia graminis tritici,* Erikss. & Henn., involves close differentiation among plants that are unlike in their reactions to rust. Differences in relative resistance and susceptibility may be detected in the greenhouse, where tests on seedlings are usually conducted, and in the nursery, where performance tests under field conditions are made.

In the greenhouse a large number of seedling plants may be tested to one form of rust in a relatively short time, but the real criterion of resistance is the reaction of plants after the heading stage under field conditions. The relationship between the seedling tests and field results after heading is of the utmost importance. If there is a definite correlation between the two when only one form of rust is present it should be possible to predict field results from the reaction of seedlings grown in the greenhouse and inoculated separately with the forms of rust occurring in the field. On account of the limited amount of seed from individual plants, this would be feasible only when there were not more than about four forms of rust to consider.

There are several reasons why it would be desirable to use the greenhouse test of seedling material as a deciding factor in the selection of resistant lines.

1. A uniformly heavy epidemic cannot be relied upon to occur in the nursery.
2. The number of physiologic forms present in the nursery and the extent to which each participates in an epidemic cannot be determined easily.
3. The field environment cannot be made uniform for all plants concerned with regard to soil topography, competition between plants, insect pests and fungous and bacterial organisms other than rust.

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4. Greenhouse tests on seedling plants can be made under controlled conditions to one form of rust at a time with very satisfactory results.
5. To test F_3 progeny of one F_2 plant to a single rust form in the greenhouse requires only the use of one five inch pot for about 27 days, whereas a nursery test of the same progeny would require one five foot row for a whole season.

Previous Work

Several rust investigators have concerned themselves during recent years with this problem. Stakman, Levine and Bailey (*11*)* in describing tests of physiologic forms of *Puccinia graminis avenae,* consider that "the reaction of seedlings to rust forms is a fairly accurate index of the reaction of older plants".

Aamodt (*1*) found that seedling reaction to particular rust forms in the greenhouse may not necessarily be a criterion of the reaction of maturing plants in the field. His studies showed that high resistance in the seedling stage in the greenhouse usually indicates resistance in the field, but moderate resistance in the greenhouse does not always mean field resistance.

In 1926 Mains, Leighty and Johnson (*8*), in a study of resistance to *Puccinia triticina* Erikss., tested plants of the cross Fulcaster × Kanred to physiologic form 9 in the greenhouse in the seedling, shooting and heading stages. Fulcaster is resistant and Kanred susceptible to form 9. They found that F_1 plants and heterozygous F_2 plants were more susceptible as seedlings than in later stages of development but that homozygous resistant or susceptible plants maintained to a large extent their respective resistance or susceptibility in all stages of development. Leighty (*7*) points out that it is of particular interest that heterozygous plants in this cross are indistinguishable in reaction in the seedling stage from homozygous susceptible plants but in the later stages show some resistance.

It is not uncommon for plants to be more susceptible to disease as seedlings than at later stages of development. Jones and Gilman (*6*) found that cabbage was much more susceptible to "yellows" in the seedling stage than at later stages of growth. It has been a general experience that flax is more susceptible to wilt in the seedling stage than later in its development. Harrington (*3*) found Pentad, a variety of durum wheat, to be moderately susceptible to forms 1 and 17 of *P. graminis tritici* in the seedling stage in the greenhouse, yet this variety when grown in the nursery at St. Paul, where a heavy artificial epidemic was created by spraying with a mixture of forms including forms 1 and 17, showed only a small amount of rust. Again, Pentad seedlings in the greenhouse showed infection running up to the 4– type when inoculated with either form 21 or 34, but when inoculated after heading in isolated muslin protected plots in the field with either of these forms no infection was secured.

Theoretically the relationship between seedling reaction to a certain form of rust in the greenhouse and the after-heading reaction of the plants to

*Reference is made by number to literature cited on page 725.

the same form under field conditions should be determined from results obtained in these places. Practically, however, the necessity of protecting the inoculated plants in the field from other forms of rust requires measures which do not allow the plant to develop naturally. Adequate protection necessitates caging the plants with heavy muslin, or using a similar device, which obviously creates abnormal conditions and tends to vitiate the value of the test. Even if medium weight muslin is used the air circulation, light and humidity within the frame are abnormal.

The purpose of the present study was to determine the extent of the correlation between the rust reaction of wheat plants in the seedling stage and the reaction of the same plants after heading to the same forms of rust.

Because of the usual impracticability of testing unprotected material to one form of rust only in the field it was decided to carry on the tests entirely in the greenhouse. The environmental conditions of temperature, humidity and light were kept as much like field conditions as possible, making the test of plants after heading at least as representative of field tests as it would be if muslin cages were used in the field. This method offered several advantages:

1. The plants would have progressive steady growth and not be set back by transplanting.
2. The soil factor could be controlled easily whereas in the field the plants would not have as uniform a soil environment.
3. The plants being in pots could be incubated in a moist chamber and moved when necessary so that all would have equal opportunity, which is not possible in the field without the aid of costly equipment.
4. The plants would be more normal in straw strength and chlorophyll content than those in field cages.

The tests were made in the greenhouse in 1926 and 1927, the 1927 work being largely a repetition of the efforts of the previous year.

Materials

Strains of the four principal varieties of wheat that are being employed in the rust resistance project at Saskatoon were used in this study. They may be described briefly as follows: Marquis Sask. 7, a strain of Marquis that probably arose through mass selection made from the original Marquis at Saskatoon by the Field Husbandry Department of the University of Saskatchewan; Marquillo Sask. 1497 (Minn. II-15-44), a vulgare variety, produced by H. K. Hayes and O. S. Aamodt from the cross, Iumillo × Marquis, at the Minnesota Agricultural Experiment Station, St. Paul, Minnesota; Iumillo Sask. 1478 and Iumillo III-25-56, selections from Iumillo, a durum variety, made by W. P. Thompson, University of Saskatchewan; Vernal Sask. 1289, an emmer variety, obtained from W. T. G. Wiener, Manitoba Agricultural College, Winnipeg.

Three physiologic forms of stem rust were used: forms 17, 21 and 36. These were all obtained as pure cultures from the Dominion Rust Research Laboratory, Manitoba Agricultural College, Winnipeg, Manitoba*. These forms were chosen because they have been prominent in Western Canada and attack Marquis vigorously. According to Newton and Johnson (*9*) form 17 was the predominating one from 1919 to 1921 and was abundant in 1922 and 1923; in 1925 and 1926 (5) forms 21 and 36 were much more prevalent than any others.

Each variety of wheat was tested to the three forms of rust. Marquillo is slightly susceptible to form 36 and resistant to forms 17 and 21. However its reactions to forms 17 and 21 are not uniform, 96% of its plants being resistant and the remaining 4% being more or less susceptible. For the purpose of this test Marquillo was divided into two types. Marquillo R (resistant) and Marquillo S (susceptible) on the basis of the reaction of seedlings in the greenhouse. Marquis Sask. 7, although morphologically not uniform in type, was uniformly susceptible to all of the forms used. Iumillo III-25-56 proved highly resistant to all three forms, but a few plants (about 4%) were susceptible. Consequently Iumillo III-25-56, like Marquillo, was divided into Iumillo R and Iumillo S for this test. Iumillo Sask. 1478 and Vernal proved to be highly resistant to all three forms of rust employed.

Methods in 1926

In 1926 the varieties tested were Marquis 7, Marquillo R, Marquillo S and Iumillo 1478. Eighteen six inch pots were used for each variety, sufficient seed being sown to insure that at least one plant in each pot would show a typical reaction to a given rust form after inoculation. Preliminary work† had indicated clearly the reactions that could be expected when seedlings of these varieties were inoculated with forms 17, 21 and 36. The planting was done on May thirteenth. The seedling plants in five pots of each variety were hand inoculated, when about two inches high, with form 17. The seedlings of a second and third set of five pots of each variety were inoculated with forms 21 and 36, respectively. The seedlings of three pots of each variety were left uninoculated to serve as controls, one for each form of rust. Details of the planting and inoculation are shown in Table 1.

Table 1:—*Details of planting and inoculation for the 1926 tests.*

Variety	Sask. No.	No. seeds planted per pot.	No. plants per pot. After thinning 1st	2nd	No. of pots used for form 17 inoc.	ck.	for form 21 inoc.	ck.	for form 36 inoc.	ck.
Marquis	7	8	2	1	5	1	5	1	5	1
Marquillo R	1497	8	2	1	5	1	5	1	5	1
Marquillo S	1497	20*	2	1	5	1	5	1	5	1
Iumillo	1478	8	2	1	5	1	5	1	5	1

*Seed of Marquillo plants which in previous tests had been found to be heterozygous in their reaction to form 17.

*Thanks are due to Dr. Margaret Newton for supplying this material.

†Unpublished results of the rust research work conducted at Saskatoon in 1925-26.

After inoculation the seedlings were kept in a moist chamber (incubated) for 48 hours to allow the rust spores to germinate and infect the plants. They were then removed to different sections of the greenhouse, a separate section being used for the seedlings inoculated with each form of rust to avoid contamination between forms. The seedlings in control pots were incubated separately from the inoculated material and placed about five yards from the plants of the tests for which they were checks.

Twenty-two days after inoculation the reactions of the seedlings were recorded. The types of infection used were those adapted by Harrington (*3* p. 268) * from the description given by Stakman and Levine (*10*). In addition the symbols 1–, 1+ and 3+ were used. Type 1– is characterized by smaller uredinia with more necrosis than Type 1. Type 1+ has larger pustules but less necrosis than Type 1. Type 3+ has medium-sized uredinia that are sometimes coalesced.

After the seedling reactions had been observed, the seedlings were thinned and transplanted as necessary leaving finally in each pot one plant which showed an infection typical for its variety. The first leaf (the only one infected) of each plant was then clipped off to prevent further infection until later heading.

Owing to the presence of mildew on the plants being tested to form 21, sulphur was dusted on them on June 17th and again on June 28th.

The material headed during the first three weeks of July and each plant was inoculated with the same form of rust as was previously used in the seedling stage. Before inoculation, however, the plants being tested to form 21 were thoroughly washed in an attempt to remove the sulphur, as Bailey and Greaney (*2*) have shown that sulphur dust is an effective control of stem rust.

After the plants had headed they were inoculated by applying urediniospores in water suspension with a fine brush; then they were incubated for 48 hours.

The reactions of the plants were recorded approximately 25 days after inoculation. The amount of rust present on the stems was noted as a per-

*The symbols herein described indicate the types of infection produced on wheat seedlings in the greenhouse by the different physiologic forms of stem rust.

o. No uredinia developed but definite hypersensitive areas present.

1. Uredinia minute and isolated; surrounded by sharply defined, continuous, hypersensitive areas; hypersensitive areas which lack uredinia may also be present.

x–. Uredinia variable; apparently includes on the same leaf blade various combinations of types o or 1 with types 2 or 3–, or all of these types.

2. Uredinia isolated and small to mid-sized; hypersensitiveness present in the form of necrotic areas in circles, uredinia often surrounded by green islands.

3–. Uredinia very small and isolated; development of rust subnormal; chlorotic areas usually present; true hypersensitiveness absent.

x. Uredinia very variable; apparently includes on the same leaf blade combinations of one or more of the o, 1 and 2 types of infection with either or both of types 3 and 4–; type 3– may also be present.

3. Uredinia small to mid-sized; coalescence infrequent; development of rust somewhat subnormal; true hypersensitiveness absent; chlorotic areas, however, may be present.

x+ Uredinia very variable; apparently includes combinations of one or more of the types o, 1, 2, and 3– with type 4 on the same leaf blade; types 3–, 3 and 4– may also be present.

4–. Uredinia mid-sized; frequently coalesced, true hypersensitiveness absent; chlorotic areas or borders surrounding uredinia frequently present.

4. Uredinia large or varying from mid-sized to large, usually numerous and confluent; true hypersensitiveness absent; chlorosis seldom present.

4+ Uredinia large and markedly confluent; hypersensitiveness and chlorosis absent.

centage. The size and vigor of uredinia were indicated by letters as follows: w= pustules wide, vigorous, often coalesced; m=pustules mid-wide, not coalescent; n=pustules narrow, isolated.

Several times during the course of the investigation the purity of the rust forms was verified by suitable tests on "differential" varieties of wheat.

Methods in 1927

In 1927 the same varieties were used as in 1926 with the following exceptions: Iumillo R and Iumillo S were substituted for Iumillo 1478 because none of the three forms of rust produced a trace of uredinia on either seedling or headed plants of Iumillo 1478 in 1926, and a repetition of such a clearcut test was not necessary. Vernal was added because it was used in the breeding work during 1926 and appeared in preliminary tests of seedlings to be slightly less resistant than Iumillo and therefore of possible interest here.

Owing to only a few seeds of Marquillo S being available for the tests, seed of a Marquillo × Marquis F_3 susceptible line was also planted. Only two seedlings of Marquillo S were found to be susceptible to form 21. The reactions of the susceptible seedlings from segregating Marquillo × Marquis F_3 plants had been found in earlier work to be similar to those of susceptible Marquillo seedlings, therefore six of the susceptible Marquillo × Marquis F_3 seedlings were substituted for the missing susceptible Marquillo plants. Similarly, four Marquillo × Marquis F_3 seedlings were used in the tests with form 36.

Only two forms of rust were used in 1927 owing to the desirability of using larger numbers of plants to each form and to the limitation of available space. Forms 21 and 36 were chosen as they were the predominating forms in Western Canada in 1925 and 1926.

The methods of planting, inoculation, etc., were the same as in 1926 with the following exceptions: The planting was done on January 18th. Artificial light was used as an aid to the natural daylight, the method employed being the same as described by Harrington (*4*) in 1926.

Eight plants of each variety, instead of five, were inoculated with rust form 21 and eight with form 36. Two check plants were grown for each test instead of one. Brush inoculation * was used on the seedlings and spray inoculation for the plants after heading. For the spraying a one quart hand sprayer was employed. No sulphur dust was used for mildew control.

The plants headed during the first half of April and were inoculated during that period. In recording the results percentage infections above 10 were recorded at intervals of 5%.

Results in 1926

The results obtained in 1926 appear in Table 2. Those from inoculations with form 21 are not comparable with the others, for the results in 1927 indicated that the sulphur dust used for mildew control in 1926 had restrict-

*Pots of plants, heavily infected with rust, were inverted and brushed lightly backwards and forwards over the seedling leaves which had been already wetted by a fine spray.

TABLE 2.—*The reactions of wheat plants to three forms of rust in the greenhouse in the seedling stage and after heading in the 1926 test.*

Variety and Sask. No.	FORM 17 RESULTS				FORM 21 RESULTS				FORM 36 RESULTS			
	Plant No.	Type of seedling reaction	Reaction after heading*		Plant No.	Type of seedling reaction	Reaction after heading*		Plant No.	Type of seedling reaction	Reaction after heading*	
			Rust % on culms	Width of pustules			Rust % on culms	Width of pustules			Rust % on culms	Width of pustules
Marquis 7	1	4	45	w+	1	4	20	m	1	4	45	w
	2	4	55	w	2	4	10	m	2	4	50	w
	3	4	43	m	3	4	20	w	3	4	42	w
	4	4	died		4	4	25	w	4	4	47	w
	5	4	43	w	5	4	injured		5	4	70	w
	Average	4	46.5	w		4	18.8	m+		4	50.8	w
Marquillo S.	1	4	22	m	1	4	10	n	1	4	20	m
	2	4	12	m	2	4	injured		2	4	12	m
	3	4	40	m	3	4	20	w	3	4	10	m
	4	4	4	n	4	4	15	m	4	4	12	m
	5	4	18	m	5	4	20	m	5	4	38	m
	Average	4	19.2	m		4	16.3	m		4	18.4	m
Marquillo R.	1	1–	0		1	3+	3	n	1	3	16	n
	2	0	t	n–	2	3	6	m	2	3+	10	n
	3	x–	t	n–	3	x	0		3	3+	10	n–
	4	1+	t	n–	4	2	7	n	4	3+	12	m
	5	1	t	n–	5	3	2	m	5	3	28	n
	Average	1	t*	n–		3	3.6	n+		3+	15.2	n
Iumillo 1478	1	0	0		1	0	0		1	0	0	
	2	0	0		2	0	0		2	0	0	
	3	0	0		3	0	0		3	0	0	
	4	0	0		4	0	died		4	0	0	
	5	0	0		5	0	0		5	0	0	
	Average	0	0			0	0			0	0	

Abbreviations: t, trace; w, wide; m, medium wide; n+, medium narrow; n, narrow; n–, very narrow.

* A trace is one per cent or less.

ed rust development after heading. But considered alone the results with form 21 are valuable in that they show for four varieties the relationship between seedling reaction and reaction after heading. Plants which as seedlings had type 4 reactions (Marquis and Marquillo S) showed after heading higher percentages of rust and wider pustules than those with type 3 as seedlings (Marquillo R) and these in turn were significantly less resistant after heading than plants which as seedlings showed type o (Iumillo).

Marquis reacted to forms 17 and 36 with type 4 infections in the seeding stage and averaged 48.7% rust infection with wide pustules after heading. Marquillo S. also reacted to these forms of rust with type 4 infections in the seedling stage but after heading it averaged 18.9% rust with medium wide pustules. It is clear that type 4 infections on seedlings indicated susceptibility after heading.

The reactions of Marquillo R in the seedling stage averaged type 1 to form 17 and type 3+ to form 36. After heading this variety averaged "trace" and 15.3% infection to the same forms, respectively. The pustules averaged narrow throughout.

The after-heading susceptibility of Marquillo plants that as seedlings gave types 3 and 3+ appeared to be different from the susceptibility of those which as seedlings reacted with type 4. The latter (Marquillo S inoculated with form 36) had distinctly broader pustules than the former (Marquillo R inoculated with form 36).

No pustules whatever were produced by either form 17 or 36 on Iumillo 1478 either in the seedling stage or after heading.

Results in 1927

The 1927 results are given in Table 3. They agree well with the findings of the previous year. Marquis and Marquillo S (including the Marquillo × Marquis F_3 susceptibles) differed little in seedling or after heading infection. Both varieties reacted to form 21 with types 4 and 4+ in the seedling stage and average around 45% rust infection with wide pustules after heading. To form 36 they gave type 4– in the seedling stage and averaged around 28% rust infection with medium wide pustules after heading. These results indicate that plants showing type 4– as seedlings are less susceptible after heading than plants giving 4 and 4+ in the seedling stage.

In 1926 Marquillo S appeared to be much less susceptible to form 36 than Marquis but in 1927 only slightly so. The reason for this is not known. It is hoped that further study may throw light on the point.

Marquillo R, in the seedling stage, averaged 1+ to form 21 and 3+ to form 36. After heading, it had 5.8% and 20.4% of rust, respectively, when inoculated with these forms. The pustules averaged medium-wide in each case. Here, plants having types 0 to 3– as seedlings were resistant after heading while plants with type 3+ in the seedling stage were slightly susceptible after heading.

TABLE 3.—*The reactions in the greenhouse in 1927 of wheat plants in the seedling stage and after heading to two forms of rust.*

Variety and Sask. No.	Plant No.	RESULTS WITH FORM 21				Plant No.	RESULTS WITH FORM 36			
		Type of seedling reaction		Reaction after heading			Type of seedling reaction		Reaction after heading	
		1st reading*	2nd reading†	Rust % on culms	Width of pustules		1st reading	2nd reading	Rust % on culms	Width of pustules
Marquis 7	1	4	4+	50	w	1	4–	4–	25	m
	2	4	4+	45	w	2	4–	4–	35	m
	3	4	4+	50	w	3	4–	4–	35	m
	4	4	4+	50	w	4	4–	4–	20	m
	5	4	4+	40	w	5	4–	4–	25	m
	6	4–	4	40	w	6	4–	4–	25	m
	7	4–	4	45	w	7	4–	4–	35	m
	8	4	4	60	w	8	4–	4–	35	m
	Average	4	4+	47.5	w		4–	4–	29.4	m
Marquillo S	1	4	4	40	w	1	4–	4–	20	m
	2	4	4+	35	w	2	4–	4–	30	m
						3	4–	4–	20	n+
Marquillo x	1	4+	4+	40	w	4	4–	4–	15	m
Marquis F_3	2	4+	4+	35	w	1	4–	4–	30	m
	3	4p	4p	40	wp	2	4–	4–	35	m
susceptible‡	4	4	4	35	w	3	4–	4–	30	n+
	5	4p	4p	45	wp	4	4–	4–	35	m
	6	4–	4	70	w					
	Average	4	4	42.5	w		4–	4–	26.9	m
Marquillo R	1	1	1–	3	n	1	3	3+	35	m
	2	0	0	15	m	2	3	3+	20	m
	3	1+	1	6	n	3	3+	3+	25	m
	4	x	x	4	n+	4	3+	3+	25	n+
	5	3§	3§	2	n	5	3	3+	20	m
	6	x	x	5	n	6	3+	3+	15	n+
	7	x–	x–	2	m	7	3–	3–	8	n
	8	1–	1–	9	m	8	3	3+	15	m
	Average	1+	1+	5.8	n+		3	3+	20.4	n+ to m

Variety and Sask. No.	Plant No.	RESULTS WITH FORM 21				Plant No.	RESULTS WITH FORM 36			
		Type of seedling reaction		Reaction after heading			Type of seedling reaction		Reaction after heading	
		1st reading	2nd reading	Rust % on culms	Width of pustules		1st reading	2nd reading	Rust % on culms	Width of pustules
Iumillo S	1	4	4	35	m	1	4	4	8	n
	2	4–	4–	20	m	2	4	4	5	n
	3	4	4+	7	n+	3	4–	4–	4	n
	4	4	4	plant diseased		4	4–	4–	10	n
	5	4	4	3	m	5	4–	4–	25	m
	6	4	4	t		6	4	4–	20	m
	7	4–	4–	t		7	4	4	15	n
	8	4	4	4	m	8	4	4	30	m
Average		4	4	10.1	m		4	4– to 4	14.6	n+
Iumillo R	1	3+	4–	4	n	1	1	1–	0	
	2	0	0	0		2	1+	1+	0	
	3	1+	1	t		3	1+	1+	0	
	4	0	0	0		4	1	1–	0	
	5	x	x–	2	n	5	1+	1+	0	
	6	3–	3–	t		6	1	1–	0	
	7	3–	x	0		7	1	1–	0	
	8	3+	3+	0		8	1+	1	0	
Average		1+	1+	t	n		1 to 1+	1	0	
Vernal 1289	1	1+	1+	t		1	1–	1–	0	
	2	1+	1	t		2	1+	1	t	
	3	1+	1+	t		3	3–	3–	t	
	4	1+	1	t		4	1	1–	0	
	5	1+	1	0		5	1	1–	0	
	6	1+	1	0		6	3–	3–	t	
	7	1+	1+	0		7	1	1	0	
	8	1+	1+	0		8	1	1–	0	
Average		1+	1 to 1+	t			1+	1	t	

* Infection 18 days after inoculation. † Infection 24 days after inoculation. § Necrosis around the pustule. p– Purple color around the pustule. ‡ Only six Marquillo S plants were available, consequently ten susceptible Marquillo x Marquis F3 plants having a similar seedling reaction to that of Marquillo S were used as substitutes.

Abbreviations: See footnote of Table 2.

In the seedling stage Iumillo S appeared to be only slightly less susceptible to form 21 than either Marquis or Marquillo S but after heading it was very much less susceptible and had narrower pustules than these varieties. Apparently type 4 infection on Iumillo seedlings indicate only slight susceptibility after heading. The results from Iumillo R and Iumillo S considered together indicate that with this variety seedling infections of types o and 3+ represent high resistance after heading and seedling infections of types 4— to 4+ may mean either resistance or partial susceptibility after heading.

Iumillo R and Vernal were highly resistant in both stages of growth. Iumillo R averaged type 1+ and 1 in the seedling stage with "trace" and 0% after heading, in its reaction to forms 21 and 36 respectively. Vernal averaged type 1 in the seedling stage and "trace" after heading with both forms of rust. The variation in the reaction of Vernal from type 1– to 3– in the seedling stage appears to have no significance genetically for all of the plants were highly resistant after heading.

Summarized Results for 1926 and 1927

The results in 1927 upheld the 1926 findings, there being close correlation between seedling reaction and reaction after heading in the material studied. Forms 21 and 36 were used both years. Summarization of the results with these forms are shown in Table 4. This table brings out the differences in infection after heading of plants that averaged types 1, 2, 3+, 4– and 4 in the seedling stage.

Table 4.—*Summarized results for 1926 and 1927 showing the reaction in the greenhouse of certain varieties of wheat in the seedling stage and after heading to rust forms 21 and 36, the predominating forms in Western Canada in 1925 and 1926.*

Variety and Sask. No.	RESULTS WITH FORM 21				RESULTS WITH FORM 36			
	No. of plants tested	Type of seedling reaction	Reac. after heading		No. of plants tested	Type of seedling reaction	Reac. after heading	
			Rust % on culms	Width of pustules			Rust % on culms	Width of pustules
Marquis 7	12	4	33.2†	w	12	4–	40.1	m+
Marquillo S*	12	4	29.4†	m+	12	4-	22.7	m
Marquillo R	12	2	4.7	n+	12	3+	17.8	n+
Iumillo‡	12	1	0.5		12	1	0.0	

* Including susceptible Marquillo x Marquis F3 plants.
† Should be higher but rust development seemed partially inhibited by sulphur dust used for mildew control in 1926.
‡ Iumillo 1478 in 1926 and Iumillo III-25-56 R in 1927; both were highly resistant.

The relationship between seedling reaction and reaction after heading is shown clearly by means of a correlation surface as in Table 5. This table contains the results obtained with forms 17, 21 and 36. Plants which, as seedlings, were highly resistant, were, with few exceptions, also highly resistant after heading. Some were only moderately resistant after heading. Plants that were moderately resistant as seedlings were either highly resistant or moderately resistant after heading. Most of the plants that appeared to be susceptible in the seedling stage showed susceptibility after heading. Some

of the plants which seemed susceptible as seedlings had less than ten per cent of rust infection after heading. Nearly all of these were Iumillo. (See Table 3).

TABLE 5.—*The relationships between the greenhouse reactions of seedling wheat plants to three forms of rust and the reactions of those plants after heading to the same form of rust.*

Seedling infection type	Percentage rust infection after heading									
	0–2	3–5	6–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79
0	17			1						
1–	9	1	1							
1	9		1							
1+	8		1							
x–	3									
3–	4		1							
x	2	2								
3	1		1	1	1					
3+	1	1		5	4	1				
4–	1	2		2	9	9				
4	2	3	1	9	7	4	12	2	1	2
4+			1			2	3	3		

Evidence on the Reliability of After-Heading Tests in the Greenhouse

In 1926 two rust nurseries, 2400 feet apart, were used. Marquillo and Marquis were sown throughout each of them as checks. Rust nursery No. 1 was sown May 19th. As the season was unfavorable for rust only a light attack developed. It was caused apparently by form 36 only as shown by a number of cultures taken from various parts of the nursery.* Marquillo averaged only a trace of rust and Marquis averaged 4 per cent. Rust nursery No. 2 was sown three weeks later than the other rust nursery and a somewhat stonger epidemic occurred. Oddly enough cultures taken from different parts of this nursery all proved to be form 21. Marquillo averaged 1.9 per cent infection and Marquis showed 11.5 per cent. A comparison of these field nursery results with the greenhouse tests reported in Tables 2 and 3 are given in Table 6.

TABLE 6.—*The relationship between after-heading infection in the greenhouse and after-heading infection in the nursery as shown by results obtained in* 1926 *and* 1927 *with two varieties of wheat and two forms of rust.*

Variety	FORM 21 RESULTS				FORM 36 RESULTS			
	Greenhouse 1927 only†			Nursery No. 2	Greenhouse 1926 and 1927			Nursery No. 2
	Seedling stage infection type	After heading		After heading. Rust %	Seedling stage infection type	After heading		After heading. Rust %
		Rust %	Width of pustules			Rust %	Width of pustules	
Marquis	4+	47.5	wide	11.5	4–	40.1	med.+	4.0
Marquillo*	1+	5.8	nar.+	1.9	3+	17.8	nar.+	trace

* The greenhouse results for Marquillo R are used since it composes 96% of Marquillo.

† The 1926 results with form 21 are not used on account of the possible influence of sulphur.

*The Dominion Rust Laboratory at Winnipeg cooperated by identifying rust cultures obtained from the rust nurseries at Saskatoon.

A comparison of the nursery results with those obtained in the greenhouse reveals a fairly close agreement between the two. From this it appears that the infection of wheat plants after heading may be obtained in the greenhouse with results fairly similar to those that would be obtained with the same variety and rust form in the field.

Discussion

The results as given in Tables 2 and 3 and summarized in Tables 4 and 5 show that there exists a strong relationship between seedling reaction and infection after heading, when both reactions are taken in the greenhouse. It is believed by the writers that reaction after heading in the greenhouse is similar to reaction after heading in the field. The evidence from the rust nurseries at Saskatoon in 1926 supports this belief.

It appears, however, that seedling reaction may indicate different things in terms of after-heading reaction (in the greenhouse) depending upon the variety of wheat concerned. For example, Iumillo S and Marquillo S both gave type 4– in the seedling stage, but after heading Iumillo S appeared to be much less susceptible than Marquillo S.

It follows from this that the use of seedling results as indications of after-heading reactions would have to depend upon the variety under consideration. In the case of hybrids it would be necessary to know how each parent behaved in the seedling and after-heading stages. Probably the after heading reaction of the hybrids would be more or less intermediate between those of the parent varieties, as appears to be the case with Marquillo. In breeding for rust resistance a few crosses are generally handled on an extensive scale and it would be quite feasible to obtain in the greenhouse in addition to the usual seedling results the after-heading reaction of each parent variety to each of the two, three or four rust forms used.

The results obtained in this study, then, are of importance in practical plant breeding for rust resistance. In the case of crosses between Vernal, Iumillo 1478, Iumillo R or Marquillo R and Marquis, the results show that F_3 seedlings having infection types 0 to 3– when under test in the greenhouse to forms 17, 21 or 36 may be classed as resistant and the seedlings showing infection types 3 and 3+ may be classed as moderately resistant to those forms in the field.

Summary

1. A study was made of the relationship between the reaction of wheat plants to stem rust in the seedling stage and the infection of the same plants after heading to the same forms of rust.

2. The greenhouse was used because of the advantages it offered for a study of this kind.

3. The investigation was carried on over a period of two years.

4. The varieties of wheat used were Marquis, Marquillo, Iumillo and Vernal, all important in the rust resistance breeding work at Saskatoon.

5. The rust forms employed were forms 17, 21 and 36, probably the three best known forms in Western Canada.

6. The results showed a distinct positive correlation between seedling reaction and infection after heading in the material studied. Plants which as seedlings had type 4 infections showed after heading higher percentages of rust and wider pustules than those with type 4– as seedlings, these in turn were less resistant after heading than plants which as seedlings showed type 3, and these were less resistant than plants with type 1.

7. It appears that seedling reactions may indicate different degrees of resistance or susceptibility in terms of after-heading reaction, depending upon the variety of wheat concerned. For the use of seedling reactions in practical breeding studies it would be advisable to obtain the reaction of each parent variety both in the seedling stage and after heading to each of the forms of rust used.

8. Plants having infection types 0 to 3– in the seedling stage were found to be resistant after heading.

9. Comparison of results from two rust nurseries, in each of which only one form of rust appeared to be present, with after-heading results from the greenhouse, where the same forms of rust were used separately, indicated that after-heading reaction in the greenhouse closely resembled after-heading reaction in the nursery.

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THE COMPARATIVE VALUE OF SCARIFIED AND UNSCARIFIED ALFALFA SEED.*

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In a previous communication† it was shown that the hard seeds of alfalfa may be considered as being almost equal in value to the permeable for securing a stand, and that the plants resulting from the hard seeds proved more winter-hardy than those from the permeable. In order to confirm the findings of that investigation regarding the ability of hard seeds to produce a stand, it was felt advisable to undertake an experiment wherein a scarified sample was compared with an unscarified under conditions more nearly approaching those obtaining on a farm. Accordingly two samples were chosen, the one machine-threshed in the ordinary way; the other scarified, but not to such an extent as to produce injury, as is evident from Table 1 which gives the laboratory germinations of the two samples.

Table 1.—*Laboratory tests on samples used.*

Sample	History	Germination after 5 days	Hard seeds	Germination as reported as basis for grading
A	Scarified	86%	10%	96%
B	Unscarified	59%	37%	96%

Plots were seeded at the Dominion Experiment Station, Lacombe, and also at the Dominion Irrigation Experiment Station, Brooks. Each locality will be considered separately.

Lacombe.

At this station four plots of 1/100 acre each were sown, two to sample *A* and two to *B*. Seeding was broadcast at the rate of 15 lbs. per acre. Counts of the number of plants per square yard were made on July 15th, 1927, seeding having been done on June 23rd previous. It was intended to make a second count at a later date, also to harvest the crop for comparison, but a severe hail-storm ruined the plots before this could be done.

Table 2 shows the results of the counts made on July 15th.

Table 2.—*Plants per square yard.*

Sample	1st Sq. Yd.	2nd Sq. Yd.	3rd Sq. Yd.	4th Sq. Yd.	Average
A	330	301	236	338	301
B	277	263	237	276	263

In considering these results it should be borne in mind that the counts were made only three weeks after sowing. The results of the paper mentioned above indicate that hard seeds do not show their maximum relative agricultural value till about two months after sowing. Nevertheless, *B* sample has produced 87% of the number of plants produced by *A*, though

*Contribution from the Laboratory Division, Seed Branch, Department of Agriculture, Ottawa, Ont.

†"The Agricultural Value of Hard Seeds of Alfalfa and Sweet Clover under Alberta Conditions."—Sci. Agr. *8* (1927) No. 4.

in the laboratory *B* only showed 69% of the germination, exclusive of hard seeds, shown by *A*. It is probable that at a later date, had it been possible to make a count then, the results obtained from the two samples would have been more nearly equal.

BROOKS.

Eight plots were seeded at this station, each consisting of 10 rows, 12 inches apart and 25 feet long. *A* and *B* samples were planted in each plot alternately.

Seeding was done on June 20th. Precipitation through the season was almost sufficient, so that only one irrigation, applied on August 5th, was necessary.

Stand counts were made on July 7th and August 3rd. For these a section of a row, 36″ long, was taken at random, the plants therein being counted. One such section was taken from each of two rows, also indiscrimately selected, from each plot.

The results of these counts are given in Table 3.

TABLE 3.—*Plants per linear yard.*

Sample	Replicate	No. Plants per 36 inch Row m(*)	Row n(*)	Average per yard each plot	Average of all plots
				(1) Count July 7th.	
A	1	32	38	35.0	
A	2	No record, as seeded too thickly.			
A	3	42	52	47.0	
A	4	44	43	43.5	42
B	1	42	47	44.5	
B	2	No record, as seeded too thickly.			
B	3	51	43	47.0	
B	4	43	48	45.5	46
				(2) Count August 3rd.	
A	1	58	56	57.0	
A	2	No record.			
A	3	50	59	54.5	
A	4	44	43	43.5	52
B	1	44	61	52.5	
B	2	No record.			
B	3	47	55	51.0	
B	4	46	43	44.5	49

(*) Rows m and n refer to any two rows in the replicate under consideration.

At the count made on July 7th the unscarified sample showed a slight advantage, but this was reversed in favour of the scarified at the count on August 3rd. The differences are so slight, however, as to be barely significant.

In the fall these plots were harvested and the yields of green fodder determined. The yields secured are shown in Table 4. Unfortunately part of each plot was damaged by stock, but the yield areas used and reported in the table were portions not affected.

Since the plots *A2* and *B2* were each sown at the same rate of seeding as the other, though more thickly than the rest, it was felt that they might be included in the yield results.

TABLE 4.—*Yields obtained from scarified and unscarified seed compared.*

Plot No.	Total lbs. green weight	Yield Area Measurements feet	Sq. Ft.	Yield per Unit Area
A 1	10.75	5.8 x 9.0	52.2	2.09
A 2	13.25	13.8 x 5.0	69.0	1.92
A 3	12.25	7.7 x 9.0	69.3	1.77
A 4	15.75	8.2 x 10.0	82.0	1.92
B 1	5.75	2.75 x 10.0	27.5	2.09
B 2	8.25	4.6 x 10.0	46.0	1.79
B 3	14.25	7.9 x 10.0	79.0	1.80
B 4	6.75	5.9 x 6.0	35.4	1.91
Average yield per unit area:—		Scarified		1.93
		Unscarified		1.90

There is seen to be a very slight advantage in favour of the scarified seed, but it is so entirely out of proportion to the difference between the laboratory germinations (exclusive of hard seeds) of these two samples as to be without practical significance.

SUMMARY.

1. In order to confirm the findings of a previously reported investigation, a supplementary experiment was carried out wherein a scarified and an unscarified sample of alfalfa were compared under field conditions more nearly approaching those obtaining on a farm.

2. Stand counts were made at the two stations at which plots were seeded, and the comparative yields of green fodder secured were determined at one station.

3. The results obtained completely supported the findings previously reported, namely, that the hard seeds of alfalfa have almost the same power of producing a stand as the permeable.

4. Taking into account the fact previously reported that the plants resulting from hard seeds of alfalfa are more winter-hardy than those from the permeable, we must conclude that unscarified alfalfa seed has at least as much agricultural value as scarified.

ACKNOWLEDGMENT

The thanks of the author are due to the officials of the Dominion Experiment Station, Lacombe, and of the Dominion Irrigation Experiment Station, Brooks, for seeding the plots and determining the yield at their respective stations and for the cordial co-operation in other respects received from them in carrying out the work reported in this paper.

Thanks are also due to Mr. G. M. Stewart, District Inspector, Dominion Seed Branch, Calgary, for co-operation in securing suitable samples.

LABORATORY OF THE DOMINION SEED BRANCH,
CALGARY, ALBERTA.

EIGHTH ANNUAL CONVENTION, C.S.T.A.

Those who had the privilege of attending the recent Convention of the Canadian Society of Technical Agriculturists at Quebec will not soon forget the many pleasant and impressive features that characterized it. From every conveivable angle it was a pronounced success. The details of organization had been carried out perfectly, the attendance exceeded even the most optimistic predictions and the weather was delightful. Those who had charge of the reception, registration, entertainment and publicity committees are to be most heartily congratulated and sincerely thanked for the manner in which they executed their duties.

It was originally intended to delay the publication of any report of the Convention until the August issue of this journal. Many of its principal features, however, can be recorded now. The next issue will contain the annual report of the General Secretary, the report of the standing committees on Research and Marketing Education, the resolutions passed at the Convention, the reports presented at the annual meeting of the Eastern Canada Society of Animal Production, as well as an outline of the meeting of the Horticulture Group of the C.S.T.A. It has been considered advisable to make a special publication of the Report of the Committee on Agricultural Policy, presented by Dean E. A. Howes, and this will be mailed to every member of the Society later in the year. The lectures given during the Convention will be published in later issues of *Scientific Agriculture*, as space permits.

Probably the most significant feature of the Convention was the fact that Laval University conferred the Honorary Degree of D. Sc. A. upon three past Presidents of the Society—Dean E. A. Howes, Dean H. Barton and Mr. L. Ph. Roy,—and that the Government of Quebec awarded the Order of Agricultural Merit to four of the Society's members— Hon. W. R. Motherwell, Dr. James W. Robertson, President L. S. Klinck and Dr. A. T. Charron. These two functions, the first at Laval University and the second at the Provincial Department of Agriculture banquet in the Chateau Frontenac, were outstanding, not only because of their dignity and impressiveness, but because of the recognition which was thus given to agricultural science by the oldest university and the oldest province in Canada.

Dr. E. S. Archibald

The business sessions of the Convention were presided over by the newly elected President, Dr. E. S. Archibald, who was introduced by the retiring President, Dr. L. Ph. Roy, at the opening meeting. The Presidential address of Dr. Roy is published in the French section of this issue. Most of the business transacted consisted of the presentation of reports which will be published later. Other important matters were as follows:—

Dr. L Ph. Roy

1. The Eastern Canada Society of Animal Production was admitted to affiliation with the C.S.T.A.

2. The following report was made by a special committee on Publications:—

"Before making certain recommendations relating to the journal of the Society, the Committee desires to express the view that "Scientific Agriculture" in its present form and content registers a very marked improvement over any previous volume. It is a credit both to the Society and to the Editor. It is evident that the journal is much appreciated by the technical agriculturists of Canada as a medium for publication and it is rapidly gaining recognition in all parts of the world.

"In view of the fact that the type of article submitted for publication as well as the centre of emphasis in certain lines of agricultural research has changed considerably in recent years, and in view of the fact that the personnel of active contributors to the journal has also altered, the Committee recommends that the proper authorities revise the personnel of the Editorial Board in the light of the above mentioned considerations. It is suggested that for each of the following subjects one or more appointments be made, depending on the number of articles in each submitted for publication and the diversity of the subject matter which they contain: Genetics and Cytology, Biometry, Plant Pathology, Plant Physiology, Economic Botany, Field Husbandry, Soils, Horticulture, Bacteriology, Entomology, Animal Husbandry, Agricultural Engineering, Economics, Dairying, Poultry Husbandry, Professional Articles. The last named subject heading is intended to take care of articles of general interest.

"There is an insistant demand that the journal devote more space to professional articles on topics of general interest such as methods in different kinds of extension work, the application of the results of research to practical problems, or non-technical reviews of the present status of certain lines of investigation. Contributions of this kind have always been welcome, but the number offered for publication has been relatively few. It is therefore recommended that the members chosen to represent this section on the editorial board, in addition to their other duties, be authorized to solicit a limited number of papers from qualified members which are not the result of the author's original research but which are nevertheless valuable contributions to professional agriculture. So-called 'popular' articles should not come under this heading.

"It is further recommended that all papers of a technical nature be read by one or more members of the editorial board before they are accepted for the journal.

"It is also recommended that, if finances permit, a slightly better quality of paper be used so that the illustrations may be reproduced more satisfactorily."

L. E. KIRK, Chairman. F. T. WAHLEN
C. E. BOULDEN H. M. NAGANT

3. A complete new set of by-laws was passed in order to meet the legal requirements for the incorporation of the Society under Dominion Charter.

4. Professor H. M. Nagant of the Oka Agricultural Institute, was awarded a Fellowship by the Society.

5. The five T. Eaton Company scholarships for 1928, amounting to $600.00 each, were awarded in accordance with the following report:—

"The Committee appointed to consider the applications for the T. Eaton Company scholarships found itself confronted with a very heavy task. After some hours' careful study of the qualifications of the thirty-six candidates, these were reduced in number to seventeen, all of whom were considered to be of scholarship calibre. Unfortunately, however, it was necessary to reduce this number to five, to correspond with the number of scholarships available. In the final selection, when the remaining candidates were so nearly equal as to make a choice between them a matter of the utmost difficulty, some consideration was given to the field of work which each condidate proposed to follow, and to the possibility of distributing the scholarships among the various branches of agriculture represented by the applicants.

The candidates finally agreed upon, after taking all relevant factors into account, represent five different branches of agriculture, and, by a coincidence, five different provinces of Canada. The latter coincidence saved the Committee any necessity of taking into account the geographical distribution of the applicants. In this connection, however, it may be of interest to report the distribution of the applications classified according to provinces of origin. This distribution was as follows:—Nova Scotia, 1; Quebec, 9; Ontario, 12; Manitoba, 4; Saskatchewan, 1; Alberta, 6; British Columbia, 3; total 36.

The following is the list of successful candidates, the names arranged in alphabetical order:—

R. H. Bedford, 10717 University Avenue, Edmonton, Alta. B.Sc. 1926, M.Sc. 1928 (Alberta). Proposed work: soil biology at McGill University.

J. R. Ferron, Institut Agricole d'Oka, La Trappe, P.Q. B.S.A. 1928 (Montreal). Proposed work: Animal Husbandry at McGill or Toronto University.

F. E. Foulds, Dominion Seed Branch, 812 Commercial Building, Winnipeg, Man. B.Sc. (Agr.) 1916 (McMaster). Proposed work: Agronomy at University of Toronto.

F. J. Richardson, Ontario Agricultural College, Guelph, Ont. B.S.A. 1926 (Toronto). Proposed work: Poultry nutrition at University of Toronto.

R. C. Russell, 433 Fifth Avenue, Saskatoon, Sask. B.S.A. 1926, M.S.A. 1926 (Saskatchewan). Proposed work: Plant pathology at University of Toronto.

The Committee has further selected a small additional group of eligible candidates, arranged in order of merit, in case any of those recommended for the scholarships should later find it impossible to go on with the proposed work.

The Committee would like to take this opportunity of expressing on behalf of all who are interested in the promotion of agricultural research in Canada, high appreciation and commendation of the important contribution made by the T. Eaton Company in creating these scholarships. The training of competent research workers is the foundational step in ensuring progress along this line. It is gratifying to find such an eagerness to take advantage of opportunities for further training, as represented in the large number of applications for these scholarships. The Committee's only regret is that such a large number of applicants of eminently suitable calibre could not be included among the successful candidates.

It should be pointed out that here is a wonderful opportunity for public-spirited firms or organizations to profit by the example of the T. Eaton Company. Agricultural research contributes in the long run to the prosperity of all classes in our country, and those who are in a position to assist in the training of young research workers may confidently regard it as an investment which will return large dividends both to themselves and their neighbours.

In this connection a suggestion has been made that a small Committee should be appointed to co-operate with the Secretary and the Executive in bringing this opportunity to the attention of firms who may be interested.

If additional scholarships should be secured this summer, there are plenty of candidates on our present list to make good use of them."

R. NEWTON, Chairman.	D. L. BAILEY	A. G. LOCHHEAD
F. PUGH	G. P. McROSTIE	GUS. TOUPIN
E. S. ARCHIBALD	L. H. NEWMAN	A. W. BAKER

6. It was decided to hold the 1929 Convention at Winnipeg, Man. This will be the second Winnipeg Convention, as the Society met there in 1921.

7. The following committees were appointed for the current year, some being named by the Nominations Committee and others by the Dominion Executive. The Chairman of each Committee is named first:

Executive Council: E. S. Archibald, A. T. Charron, L. H. Newman, F. T. Wahlen, R. S. Duncan, G. C. Creelman, H. M. Nagant, J. E. Lattimer.

Research: G. P. McRostie, G. G. Moe, R. Newton, William Allen, A. Cairns, F. N. Marcellus, J. F. Snell, H. M. Nagant, J. M. Trueman.

Affiliations: L. H. Newman, T. G. Major, Arthur Gibson.

Agricultural Policies: E. A. Howes, F. H. Auld, W. B. Roadhouse, H. Barton, C. F. Bailey, E. S. Archibald, G. H. Clark.

Marketing Education: F. M. Clement, D. A. McGibbon, A. M. Shaw, H. C. Grant, W. H. J. Tisdale, J. Coke, P. A. Fisher, H. S. Arkell, J. E. Lattimer, J. B. Cloutier, W. V. Longley, J. A. Clark, H. C. Bois.

Educational Policies: L. S. Klinck, with power to add to his committee.

Membership: G. C. Creelman, Georges Maheux, F. T. Wahlen.

Finance: R. S. Duncan, W. T. Hunter, R. W. Maxwell.

Progress: J. Macgregor Smith, W. T. G. Wiener, D. C. Schurman.

Ballot: A. T. Charron, L. H. Newman.

Auditors: H. G. Crawford, G. LeLacheur.

Representative on Council of A.A.A.S.: F. H. Grindley.

One can safely say that, in spite of the importance of the business meetings, the Quebec Convention will be remembered by its social aspects. Over three hundred and fifty members were present and as there were nearly one hundred ladies and a considerable number of non-member guests, the total registration was approximately five hundred. This is more than twice the attendance at the next largest Convention, the one held at Ottawa in 1926. That this huge crowd was handled at luncheons and banquets, on motor trips and on boat trips without any difficulty or confusion serves to emphasize the completeness with which the organization work was carried out.

Starting with a luncheon at noon on the opening day, a tea for the ladies in the afternoon and a business banquet in the evening, the members were treated to an almost continuous demonstration of the hospitality and entertainment for which Quebec is so well known. In many staid journals of this kind some features of the social programme might be omitted, but we prefer to give prompt recognition now to the following:—(a) The genial willingness of those at the registration booth who, though often overcrowded, were always cheerful and obliging, (b) the training given by Georges Maheux to those not familiar with French-Canadian *chansons*, (c) the excellent entertainment provided by Mme. Duquette and her pupils at the banquet on June 11th and by the one and only Charles Marchand of folk-song fame at the banquet on June 13th, (d) the efficiency of Narcisse Savoie and Leo Brown in their respective reception duties, (e) the orchestra and old-time fiddler on the boat excursion that closed the convention and (f) the mysterious and effective manner in which the guiding hand of Maurice Talbot functioned everywhere.

On Thursday, June 12th, ninety automobiles conveyed four hundred conventionists on the ferries to Lévis and through seventy-five miles of Old Quebec to Ste. Anne de la Pocatière. This outing warrants special mention. Leaving Lévis, the cars drove along the banks of the St. Lawrence and after covering about ten miles, each car was stopped at a marked booth, each pas-

senger furnished with a complimentary picnic lunch and then the journey continued. The long line of automobiles was skirted by motor police directing those strange to the road and even a "repair" car was available for those who had any car trouble. Arriving at Ste. Anne during the afternoon there was ample time to visit the Dominion Experimental Station. At five o'clock the entire party of four hundred was hospitably and lavishly entertained at dinner by the staff of the Agricultural School. The return trip was started in time to bring everyone to the Chateau by eleven o'clock.

At noon on the 13th, following the close of business meetings, the same chain of cars left Quebec and their occupants were entertained for luncheon at the Dominion Experimental Station at Cap Rouge, ten miles from Quebec. Following an inspection of the Station an opportunity was afforded to all of visiting the historic parts of Quebec, Montmorency Falls, Ste. Anne de Beaupré, etc.

The Quebec Department of Agriculture banquet, held at 7.30 in the evening, stands out as the *coup d'etat* of the Convention. Attended by Prime Minister Taschereau and by Church, State and Civic dignitaries, presided over by the Hon. J. E. Caron, Minister of Agriculture, and with over five hundred guests present, the banquet hall presented a spectacle never to be forgotten. The various courses on the menu (and they were many) were punctuated by orchestral music and by the songs of Charles Marchand. The toasts were proposed by Mr. Caron ("Our Guests"), Dean Howes ("Quebec") and President Klinck ("Laval") and replied to, in the same order, by Dr. Archibald for the C.S.T.A. and Major Strange for the Canadian Seed Growers' Association, Hon. H. La Ferté, Deputy Speaker in the Provincial Legislature and Monsigneur Camille Roy, ex-Rector of Laval and President-elect of the Royal Society of Canada.

The entire day on Thursday was devoted to lectures and group meetings in Field Husbandry, Horticulture and Animal Husbandry, one group being at the Chateau and two in the Parliament Buildings. The lectures given by Dr. A. Volkart, Dr. E. C. Auchter, Dr. E. C. Stakman, Dr. R. J. Garber and Dr. John D. Black, as well as many of the papers and reports given at these group meetings will, we hope, be available for publication at an early date so that all members may have an opportunity of studying them.

Georges Maheux

On Thursday evening the Convention was suitably closed by an almost impromptu boat trip on the St. Lawrence to Quebec Bridge and Orleans Island. Songs were sung, dances were danced, and the three hundred who were present agreed that they were "happy to meet, but sorry to part." And from a window in the Chateau Frontenac, where for four days the C.S.T.A. members had made their home, one could hear the boat party landing at the dock and could imagine Georges Maheux standing on the Captain's bridge leading in the French Canadian's parting song, "Bon soir, mes amis, bon soir!"

F.H.G.

EASTERN CANADA SOCIETY OF ANIMAL PRODUCTION.

The first annual general meeting of the Eastern Canada Society of Animal Production was held in the Chateau Frontenac, Quebec on June 14th, 1928.

The sessions which were attended by approximately seventy-five members, were presided over by the Acting President, Dean H. Barton, Macdonald College, Que.

Reports were presented by the chairmen of the standing committees on Horse, Beef Cattle, Dairy Cattle and Sheep and Swine Production and papers were read by Dr. W. J. R. Fowler, Ontario Veterinary College, Prof. J. C. Steckley, Ontario Agricultural College, J. K. King, Moncton, N.B. and L. C. McOuat, Ottawa. The reports and papers were of a comprehensive and instructive nature and a great many members, who previously were inclined to be skeptical regarding the future of the Society, voiced the opinion that, if the work which was being done by the various standing committees could be continued, the organization would be performing a very useful service for animal husbandry workers in Eastern Canada. These reports will be published in the August issue and the papers will be published at a later date.

The meeting paid a tribute to the memory of the late Professor Wade Toole, the first President of the Society, whose death was a great loss not only to the Society but to the animal industry of Canada.

In connection with improving the work of the Society, it was agreed that, in future, reports of standing committees should be in the hands of the Secretary before the annual meeting and that copies should be submitted to the members previous to the meeting. It was further agreed that in future the reports of Committees should deal with the specific field covered by the Committee in the previous year and recommendations as to the particular problems to be dealt with in the ensuing year.

The meeting also endorsed the recommendation of the Beef Cattle committee in regard to the need of survey and investigational work to obtain definite information on beef production costs under varying farm conditions and systems of management, and recommended that a sub-committee of the Beef Cattle Production committee be appointed to give special and immediate attention to the obtaining of such required data in an organized way.

Two new standing committees were appointed, one on Experimental Methods and the other on Animal Health. The following comprises the personnel of the various standing committees for 1928-29, the Chairman in each case being named first:—

Horse Production—C. M. MacRae, C. F. Bailey, J. J. Gautreau, R. W. Wade.

Beef Production—R. S. Hamer, W. W. Baird, E. W. Crampton, J. C. Steckley.

Dairy Cattle Production—A. R. Ness, J. M. Trueman, J. A. Ste. Marie, W. J. Bell.

Sheep Production—A. A. MacMillan, A. E. MacLaurin, X. N. Rodrigue, L. E. O'Neill.

Swine Production—G. B. Rothwell, A. W. Peterson, S. J. Chagnon, I. B. Martin.

Animal Health—Dr. A. E. Cameron, Dr. Lionel Stevenson, Dr. R. L. Conklin.

Experimental Methods—Committee to be named by the executive.

The election of the officers of the Society resulted in the following being elected: President, Dean H. Barton; Vice-Presidents, J. M. Trueman, S. J. Chagnon; Directors: A. W. Peterson, Gustave Toupin, J. C. Steckley; Secretary-Treasurer: L. C. McOuat.

L. C. McO.

ALLOCUTION PRESIDENTIELLE*

L. Ph. Roy

L'usage depuis huit ans établi, veut qu'à chaque congrès annuel de notre société, le président sortant de charge soit invité à prononcer un discours de retraite. Ce privilège lui fournit l'occasion de faire, devant les membres réunis, l'exposé du travail accompli durant son terme d'office et de suggérer, à loisir, des réformes ou initiatives nouvelles. Puis-je ajouter que, dans mon cas, cette invitation me porte singulièrement à méditer sur la brièveté de la gloire humaine.....Les honneurs inattendus que me prodigua mon agréable tâche, de même que l'empressement avec lequel on s'appliqua, durant les douze mois écoulés, à m'éviter les besognes les plus difficiles, contribuèrent, je crois, à me faire perdre un peu la notion du temps. Aussi, vous prierais-je de ne manifester aucune surprise, si je crois devoir avouer qu'après m'être mêlé plus intimement aux gens et aux choses de notre société, un seul devoir m'a semblé pénible à accomplir: ce fut l'impérieuse nécessité de quitter le fauteuil après le terme expiré.....Je puis toutefois vous assurer que ces considérations d'ordre plutôt sentimental se sont bien vite dissipées lorsque le résultat du dernier scrutin nous appris que le nouveau président élu était celui que l'on connaît tous pour être l'un de nos meilleurs maîtres en agronomie au Canada, et qui, par son travail vigilent, est devenu l'animateur de la plus grande organisation de recherches et de propagande agricole que nous ayons au pays.

Notre société compte aujourd'hui huit années d'existence. Au cours de ce laps de temps, elle a non seulement vécue mais elle a prospéré chaque année. Sa marche ascensionnelle se traduit par un graphique qui gravit progressivement le sommet. Il en est peut-être des associations comme des revues nouvelles qui surgissent: elles peuvent naître presque spontanément ou sous l'effet d'un enthousiasme passager, mais seules celles qui ont une mission à servir peuvent subir l'épreuve du temps.

Jamais la raison d'être de la Société des Agronomes canadiens ne m'est apparue mieux justifiée que lorsque j'entendis, l'an dernier, l'un de nos membres de l'Alberta m'exprimer l'idée que nous pourrions lui donner le motto de *"Unselfish Service to Agriculture"*. Ces quelques mots traduisent, on ne peut mieux, toutes nos aspirations.

Lorsque nous avons fondé cette association, nous avons non seulement rendu solidaires entre eux les meilleurs auxilliaires des cultivateurs dans notre pays, mais nous leur avons aussi fourni le moyen de travailler en commun à leur perfectionnement professionnel de façon à ce que les intérêts agricoles soient mieux servis. Nous nous sommes par ailleurs toujours gardés, dans l'élaboration de notre constitution de même que dans la conduite de nos délibérations, d'entacher notre société du moindre caractère d'égoisme ou de tendances tracassières à l'égard des autres classes de la société.

*Prononcée à Québec, lors de la huitième convention annuelle de la C.S.T.A.

Si nous prenons la peine de lire le texte des allocutions prononcées par nos présidents-pionniers, nous nouvons constater, qu'à défaut de pouvoir commenter longuement le passé de notre société, alors naissante, ils pensèrent à nous léguer le fruit de leur expérience. Leurs exposés remarquablement lucides, soulignent les grands problèmes de notre profession et établissent les cadres dans lesquels cette société est appelée à exercer son action.

Mais au fur et à mesure que les années s'ajoutent à son passé, notre association voit surgir de nombreux problèmes nouveaux, et s'agrandir le champ de ses activités. Forcée, par des débuts difficiles, à s'engager rapidement sur le chemin de l'action, elle eut tôt fait de produire des oeuvres. Le bilan de ce qui a été accompli, au cours du dernier terme, en est une preuve indéniable. Aussi croyons-nous convenable d'en attribuer surtout le mérite à ceux qui, avant nous, présidèrent aux destinées de la société des agronomes canadiens.

Activites de 1927-28

Dans son rapport annuel, votre secrétaire soulignera d'une façon spéciale quelques initiatives nouvelles qui reçurent l'attention de l'exécutif. Je ne ferai qu'en donner rapidement un aperçu pour pouvoir mieux faire ressortir ensuite les développements nouveaux qui s'imposent au sein de notre association professionnelle:

1. *Incorporation*:—Après huit ans d'opération et suivant le désir maintes fois exprimé par les membres, il fut possible d'obtenir l'incorporation de notre société sous une charte fédérale. Cette formalité, devenue nécessaire, donnera, dorénavant, au corps des techniciens agricoles, son statut légal au pays, et permettra à notre association de prendre place au milieu des groupements professionnels déjà reconnus. Ceux de nous qui ont à coeur de voir grandir le prestige de la profession agricole, reconnaîtront peut-être dans cette tentative, le dessein bien arrêté de notre société de s'appliquer à toujours mieux faire connaître et apprécier, dans notre pays, l'utilité des études agronomiques.

2. *Transformation de la "Revue Agronomique Canadienne"*:—Grâce à une meilleure situation financière, et, aidé généreusement par plusieurs institutions fédérales et provinciales, votre exécutif a pu réaliser, cette année, une urgente amélioration de notre revue. Non seulement le nombre de pages en fut augmenté, mais on en a grandement aussi amélioré le ton et la tenue typographique. Cette transformation était devenue nécessaire pour faciliter aux membres la publication d'articles originaux de même que l'exposé de travaux de recherches faites au pays. Ces écrits, en raison de leur caractère purement technique, pouvaient jusqu'alors, difficilement trouver asile dans nos périodiques agricoles, ce qui déterminait trop souvent leurs auteurs à en tenter la publication à l'étranger. Il nous est donc devenu facile d'offrir aujourd'hui une large hospitalité à nos collaborateurs, et l'organe officiel de notre société peut se comparer avec les publications scientifiques agricoles des autres pays. Il nous est agréable de constater que des extraits de notre revue sont fréquemment mis en circulation dans a presse agricole mondiale. Nous ne saurions trop souhaiter que l'assistance qui nous

est donnée pour garder à cette publication son caractère actuel, soit continuée aussi longtemps que nos conditions financières ne nous permettront pas d'en assumer la totalité du coût. On nous fait occasionnellement remarquer que notre revue pourrait mieux servir les intérêts des membres si, au lieu de garder son caractère technique, elle acordait une plus large place aux articles de vulgarisation agricole du genre de ceux que publie la presse rurale. Je suis personnellement heureux de voir triompher, parmi nous, l'idée de laisser notre revue ce qu'elle est, et d'attacher toujours plus d'importance à sa valeur scientifique. Rien nous justifierait, me semble-t-il, d'essayer à imiter ou concurrencer une presse agricole déjà bien établie dans chaque province, et qui est plutôt destinée à communiquer à notre classe rurale les connaissances élémentaires agricoles.

3. *Bourses Pour Etudes Post-Scolaires*:—On ne pourrait passer sous silence l'acte de générosité par lequel la maison T. Eaton Co. nous octroya dernièrement cinq bourses de $600.00 chacune et pour une durée de trois ans. Cet événement heureux permettra à plusieurs candidats de poursuivre leur entrainement dans les travaux de recherches agricoles. Ce fut en outre pour notre société l'occasion de se faire reconnaître officiellement comme médium tout désigné l'occasion de se faire reconnaître officiellement comme médium tout désigné pour recevoir certains encouragements destinés à des travaux de recherches dans le domaine de l'agriculture technique. Nous tenons à remercier publiquement la maison qui nous accorda ces gratifications pour son geste sympathique envers notre société et nos gradués.

4. *Gratification Rockefeller*:—Nos membres se sont rendu compte, depuis quelques années déjà, de l'urgence de faire faire un relevé dans les différentes institutions agricoles du Canada, à la fin de connaître les facilités offertes par chacune d'elles pour y poursuivre des études post-scolaires. Un comité, à cet effet, fut nommé, durant les années passées, et sur sa recommandation, nous pûmes obtenir, de la fondation Rockefeller, l'assistance voulue qui permettra à l'un de nos membres de se charger de ce travail au cours de la prochaine année. Il nous est agréable de savoir que cette tâche sera confiée à M. le docteur Robert Newton, attaché à la faculté d'agriculture de l'Université d'Alberta.

5. *Un Assistant Permanent au Secrétariat Général*:—Depuis les débus de notre association et jusqu'à 1927, notre secrétaire général dut effectuer seul une besogne de plus en plus absorbante. Notre situation financière ne nous permettait pas de lui fournir de l'aide d'une façon constante pour son travail de routine. Peu de nous ont été en mesure d'apprécier jusqu'à quel point cette charge était devenue lourde et captivante pour M. Grindley qui, de temps en temps, doit s'absenter dans des voyages à travers le Canada, en vue de maintenir l'activité des différentes sections. Nous avons pu rémédier à cette lacune cette année d'une façon satisfaisante. Notre secrétaire pourra maintenant consacrer plus de temps à l'étude des problèmes nouveaux.

En dépit de certaines entreprises onéreuses qui ont dû être poursuivies au cours de l'année dernière, notre situation financière s'est maintenue avec un joli surplus en caisse. Par ailleurs, l'effectif de nos membres est demeuré aux environs de 1000 ce qui correspond à l'objectif que s'était tracé les fondateurs de notre association.

Différents problèmes réclameront, au cours de l'année, l'attention du nouvel exécutif. Au nombre de ceux-ci, qu'on me permette de signaler que les quartiers-généraux de notre secrétariat général devraient être améliorés, dans le plus bref délai possible. Nous comprenons toutefois que c'est là un problème difficile à résoudre, étant donné surtout le peu de probabilité de voir les revenus de notre société augmenter sensiblement, sous le régime actuel. Abuserai-je du privilège que m'accorde la circonstance en exprimant le désir de voir un jour la contribution annuelle des membres redevenir à $10.00 par an, tel qu'il avait été résolu au début. Plusieurs de ceux qui ont toujours eu confiance dans une organisation professionnelle du genre de celle que nous avons aujourd'hui, pensent avec raison que nous ne devons pas hésiter à faire quelques sacrifices envers notre association si nous voulons qu'elle atteigne son plein développement. Le système de souscription actuel correspond, à mon sens, à la ration d'entretien. Si nous l'augmentions de $5.00 par membre et par année, la société pourrait accomplir beacoup plus pour chacun de nous, et elle ferait par ailleurs meilleure figure vis-à-vis des autres groupes professionnels.

Il deviendra convenable, d'ans l'avenir, que notre société puisse aider efficacement à orienter les carrières de nos gradués sortant des collèges d'agriculture. Personne de nous n'ignore que c'est là un des problèmes auquel nous avons déjà songé et que nous devrions avoir particulièrement à coeur. Or il est évident qu'il existe une foule de sphères où nous pourrions déployer une plus grande activité et exercer plus d'influence. Les industries et nombres d'entreprises commerciales qui ont quelques chose de commun avec l'agriculture devraient être, au point de vue d'un bureau de placement, de belles perspectives à étudier. Il est également à prévoir et à désirer que durant la prochaine décade, les gradués des collèges agricoles songeront de plus en plus à se diriger vers l'exploitation de domaines ruraux. Ce sont là, il me semble, autant d'occasions pour notre société, lorsqu'elle aura pris l'ampleur suffisante, d'exercer son action bienfaisante vis-à-vis de ses membres, en leur facilitant l'accès à des emplois plus variés et en leur évitant les plus grandes difficultés du début.

Le temps serait peut-être bientôt venu aussi de songer à l'assurance-groupe parmi nos membres ce qui devrait être un excellent moyen de recrutement de membre à vie et de donner plus de stabilité à notre société.

En considération de ce que notre société a fait et est en mesure de faire pour le prestige et la bonne renommée de notre profession, puis-je vous demander de lui acorder votre confiance et votre appui. Soyons-lui loyaux et donnons-lui, dans la mesure de nos moyens, notre contribution individuelle et ce sera là un excellent de bien servir la cause de l'Agriculture.

Notre société se compose de deux groupes distincts: l'un, plus nombreux, de race anglaise, et l'autre de race française et, chacun le sait, ces deux éléments formant la même unité, ont toujours travaillé, dès le départ dans la plus vive harmonie. Cet excellent état d'esprit et cette collaboration fraternelle doivent se maintenir dans notre intérêt commun. Et, messieurs, permettez-moi de vous dire aujourd'hui, qu'une des joies de mon terme de président, ce fut de contribuer de toutes mes forces à fournir l'occasion aux membres de notre province de donner l'hospitalité à nos confrères de longue anglaise réunis avec nous en congrès. Cette magnifique réunion chez nous aidera fortment, croyons-nous, à faire mieux connaître et apprécier nos membres québecois. Elle nous permettra de nous convaincre que chacun de nous peut, selon ses talents et ses mérites, son caractère et ses légitimes aspirations, aider à réaliser, au moyen de notre large devise, le programme de notre association, qui est de travailler au progrès agricole et de grandir, dans l'estime de tous, le prestige de notre profession.

LA CONVENTION DE QUEBEC

Voilà la huitième convention de la C.S.T.A. entrée dans le domaine du passé. Nous ne voudrions pas anticiper sur le rapport complet et circonstancié qu'en fera le dévoué Secrétaire général de notre association dans le numéro d'août de la Revue Agronomique, en donnant un aperçu qui ne serait pas digne de l'évènement.

Constatons seulement que tous les membres de notre association professionnelle peuvent être fiers de cette magnifique et féconde manifestation qui a été un succès sans précédent dans les murs de la vieille capitale. Tous ceux qui y participèrent ont emporté, nous en sommes convaincus, un souvenir aussi charmant que réconfortant de ces assises où des techniciens agricoles venus de toutes les provinces de notre vaste Dominion ont fraternisé de la manière le plus cordiale pendant quatre jours, travaillant avec ardeur dans les sections et comités à la solution de problèmes vitaux de notre organisation technique agricole, écoutant nombre de conférences et rapports aux assemblées générales et dans les réunions de groupes, se récréant de tout coeur au cours des réunions intimes te des magnifiques excursions qui ont signalé la convention.

Parmi tant de belle choses, les suivantes resteront surtout marquées en lettres lumineuses et ineffaçables dans le mémoire des techniciens agricoles qui eurent l'avantage de se réunir dans la cité de Champlain: Le cadre incomparable du "Château Frontenac" avec sa terrasse de renommée mondiale, ses salles somptueuses et ses appartements confortables, qui en font un endroit idéal pour la tenue d'un congrès; l'impressionnante cérémonie de la remise des diplômes de Docteur en Sciences Agricoles à trois de nos confrères, dans le grand auditoire de la vénérable Université Laval; la magnifique excursion à Ste. Anne de la Pocatière et la réception royale qu'on y reçut de la part du collège classique et de l'Ecole d'agriculture; la visite à la Ferme expérimentale du Cap Rouge, et, comme couronnement, le splendide banquet de plus de 600 couverts offert par le Ministère de l'Agriculture de la province de Québec au Château Frontenac. Ce magnifique résultat, nous le devons à la collaboration étroite de toutes les puissances de tous les talents et de toutes les bonnes volontés qui se sont unis à Québec pour faire de la huitième convention de la Société des Agronomes Canadiens ce que nous osons appeler une apothéose de la technique en agriculture.

Aussi éprouvons-nous en tout premier lieu le besoin d'adresser nos plus sincères remerciements au gouvernement de la Province de Québec et particulièrement à son Honorable Ministre de l'agriculture ainsi qu'à son son Sous-ministre qui ont accordé le si généreux appui matériel et moral indispensable à la réussite de la convention. Toute notre reconnaissance va aussi aux autorités de l'Université Laval, qui une fois de plus ont saisi l'occasion d'honorer la Science agricole en couronnant solennellement trois des membres les plus méritants de notre association. Nous ne nous sentons pas moins obligés envers le Collège et l'Ecole d'agriculture de Ste. Anne de la Pocatière pour la belle réception et le plantureux banquet servi avec

tant de générosité lors de la visite de ces belles institutions qui ont fourni à nos hôtes un remarquable exemple de la puissance de l'enseignement classique dans la province de Québec et de sa collaboration avec la science agricole.

Nul n'ignore non plus tout ce que la Société des Agronomes canadiens doit à son Président général sortant, Louis-Philippe Roy, qui a été l'animateur de la convention dont il a pris les principales initiatives.

Enfin il est plus malaisé encore de rendre justice au mérite de chacun des membres de la Section de Québec de la C.S.T.A. pour la somme de travaux et de sacrifices qui ont assuré le brillant succès de la convention. Comme le faisait si bien remarquer monsieur Ls.-Ph. Roy, dans son discours présidentiel, en nommer quelques- uns serait manquer de justice envers les autres, parce que tous ont rivalisé d'ardeur dans les différents comités. Si l'activité et le dévouement des uns était plus visible parce que s'exerçant sur la scène, ceux des autres, qui se manifestaient dans les coulisses, n'étaient pas moins méritoires.

La section de Québec a donné un magnifique exemple de ce que peut réaliser pour le bien général d'une association ce véritable esprit de solidarité, dans lequel l'avantage personnel et le bénéfice immédiat sont subordonnés au but principal à atteindre.

Parmi les éléments de succès de la convention, il y aurait lieu aussi de mentionner le "Rus", journal plein de brio, publié sous la direction de nos confrères Alphonse Désilets et Norris Hodgins, qui fut un facteur non négligeable à l'entretien de la bonne humeur et de l'entrain des congressistes. Nous pensons ne pouvoir mieux conclure les quelques remarques formulées plus haut que par les voeux que nous empruntons au numéro du 13 juin du Rus.

"Nous souhaitons maintenant que les effets de ces assises se prolongent à travers le pays, avec une foi plus vive en nos moyens professionnels d'avancer l'agriculture scientifique et pratique dans le Canada. La C.S.T.A. demande que chacun de ses membres soit fier d'appartenir à l'association et ne craigne pas d'en parler, que chacun mette en jeu tous ses talents pour donner à son travail le maximum d'efficacité; enfin que la "Revue agronomique", les séances techniques, les assemblées de sections et les conventions générales soient de mieux en mieux suivies. Et nous espérons que nos confrères des autres provinces emporteront une excellent souvenir de leur séjour parmi nous et une bonne impression des activités agricoles de la province de Québec".

H. M. N.

Notes.

Le R. Fr. Gabriel, professeur-agrégé de zootechnie à l'Institut Agricole d'Oka, a obtenu avec grande distinction, son diplôme de Docteur en médecine vétérinaire à la Faculté de médecine vétérinaire de l'Université de Montréal.

Le diplôme de Ph.D. (correspondant au titre français de Docteur en Sciences Naturelles) de l'Université Harvard a été a conféré au R. P. Louis-

Marie, professeur de botanique à l'Institut Agricole d'Oka, à la suite de la présentation d'une thèse portant sur l'étude des graminées dans l'Amérique du nord.

Monsieur Lucien Therrien, jusqui 'ici sous-inspecteur de district à Louiseville, a accepté la position de propagandiste dans le province de Québec pour la N. V. Potash Export My. of Amsterdam qui a ouvert récemment un bureau canadien à Montréal.

Monsieur Elphège Marseille, agronome officiel à Berthier, remplacera monsieur Lucien Therrien en qualité de sous-inspecteur de district.

Monsieur Robert Raynauld, B.S.A., de l'Institut agricole d'Oka, qui continuait des études de "post-graduate" au Collège Macdonald, a obtenu le titre de M.S.A., à cette institution. Monsieur Raynauld a spécialisé en Agronomie et a présenté une thèse "sur l'influence du facteur variété dans le pourcentage d'écale de l'avoine."

Toutes nos félicitation pour les succès remportés et les promotions obtenues.

VERS LA PRODUCTION D'ENGRAIS DE PLUS EN PLUS CONCENTRES.

On annonçait récemment l'expédition aux Etats-Unis d'une cargaison d'un nouvel engrais composé, préparé spécialement pour les besoins de l'Amérique par le Syndicat ellemand de l'azote, dénommé Nitrophoska no. 3, et dosant 64.2% d'éléments fertilisants totaux.

Ce produit qui est une association de nitrate de potassium et de phosphate d'ammonium contient 15.9% d'azote, 32% de P_2O_5, et 16.3% de K_2O. La proportion des principes nutritifs correspond donc approximativement à celle que l'on trouve dans un engrais composé ordinaire de la formule 4-8-4, mais avec cette différence que la concentration en est quatre fois plus forte, de sort qu'il ne faudrait que 100 lbs de Nitrophoska no. 3 pour équivaloir à 400 ibs. d'engrais 4-8-4.

FORMATION DE ZEOLITES ET REACTIONS PAR ECHANGE DE BASES DANS LE SOL.

Bulletin technique no. 15 de la Station Agricole de l'Arizona 1927, par P. S. Burgen et W. T. McGeorge.

Dans ce bulletin, qui est la continuation de traveaux antérieurs, il est fait rapport de différentes expériences et notamment de la préparation de zéolites artificielles par réaction mutuelle d'aluminate de sodium et de silicate de sodium, avec remplacement subséquent du sodium contenu dans le précipité, par du calcium au moyen d'échange de base avec du $CaCl_2$.

Les auteurs concluent de ces expériences que la formation de zéolites dans le sol peut être attribuée en grande partie aux réactions mutuelles d'aluminates solubles et de silicates, que les zéolites doivent être considérées comme des composés chimiques définis, susceptibles d'être ionisés, et que les échanges de bases dans le sol doivent être considérés comme des phénomènes de double décomposition plutôt que des actions d'absorption physique.

En plus des expériences citées plus haut, les auteurs ont fait une étude du pouvoir d'échange de bases de la matière organique du sol. La conclusion en fut que la matière organique du sol ne possède pas une véritable faculté d'échange de bases, mais qu'il s'agit ici plutot d'un pouvoir d'absorption physique des principes dissous. (Experiment Station Record.)

CONCERNING THE C.S.T.A.

Notes and News.

Dr. J. B. Reynolds (Toronto '93), who has been President of the Ontario Agricultural College since 1920, has resigned. The vacancy has been filled by the appointment of Dr. G. I. Christie (Toronto '02), formerly Director of the Agricultural Experiment Station at Purdue University, Lafayette, Indiana.

We regret to announce the death of two members of the Society during the month of June. George H. Hutton (Toronto '00) Superintendent of Agriculture and Animal Industry for the Canadian Pacific Railway at Calgary, Alta., died suddenly in Montana on June 7th. Charles W. Baxter, formerly Dominion Fruit Commissioner and General Manager of the Niagara Packers Ltd. since 1921, died at his home in Grimsby, Ont. on June 9th.

R. Harcourt (Toronto '93) recently received an Honorary Doctor's degree from the University of Western Ontario. He is Professor of Chemistry at the Ontario Agricultural College.

A portrait of Dr. G. C. Creelman (Toronto '88) painted by Ed. Marsh of Toronto, was presented to the Ontario Agricultural College at a reunion of the O.A.C. alumni on June 23rd. Dr. Creelman was President of the College from 1904 until 1920 and the portrait was financed by contributions from nearly eight hundred graduates of the College, resident in fifteen different countries.

G. D. Matthews (McGill '21) who has been Assistant Superintendent at the Dominion Experimental Farm, Indian Head, Sask., for the past five years, has been appointed Superintendent of the Dominion Experimental Farm at Scott, Sask., to fill the vacancy caused by the death of his brother, Victor Matthews (McGill '13).

E. G. Bayfield (Alberta '23) is at the University of Minnesota taking graduate work leading to his Ph.D. His address is c/o Division of Agricultural Biochemistry, University Farm, St. Paul, Minn., U.S.A. He has been Agronomist at the School of Agriculture, Claresholm, Alta. since 1924.

Wilfred Robinson (Alberta '26) is now Agronomist at the School of Agriculture, Claresholm, Alberta.

Arthur Dumais (Laval '17) has been appointed a District Representative in Saskatchewan. His new address is 480 Second Avenue, Saskatoon, Sask.

U. Phaneuf (Montreal '22) who was County Agriculturist at Rimouski, P.Q. has been transferred to Berthierville, P.Q.

C. J. Watson (McGill '21) has returned to the Central Experimental Farm, Ottawa, from Cornell University where he recently received his Ph.D. degree. He is Assistant Chemist at the Central Experimental Farm.

T. C. Vanterpool (McGill '23) has been appointed Assistant Professor of Biology at the University of Saskatchewan, Saskatoon, Sask., where he will be located after July 1st.